THE INSTITUTE OF PETROLEUM REVIEW

vol. 14 #165

September 1960

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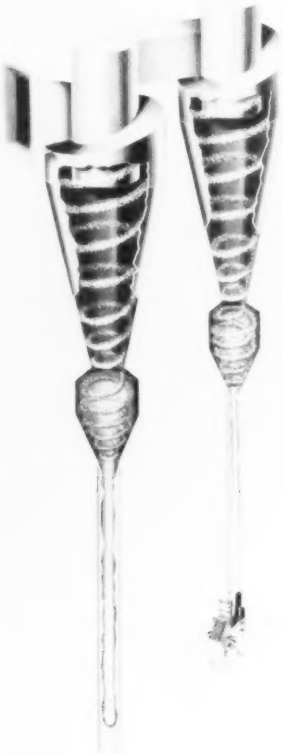

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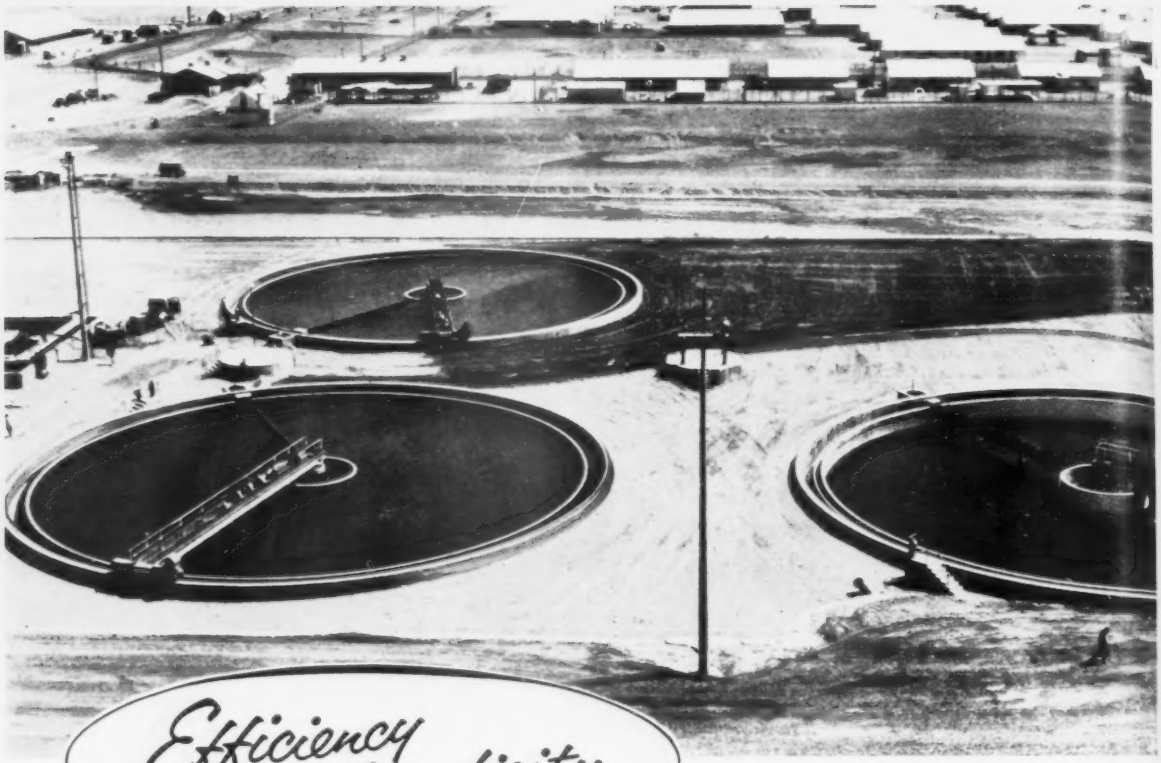

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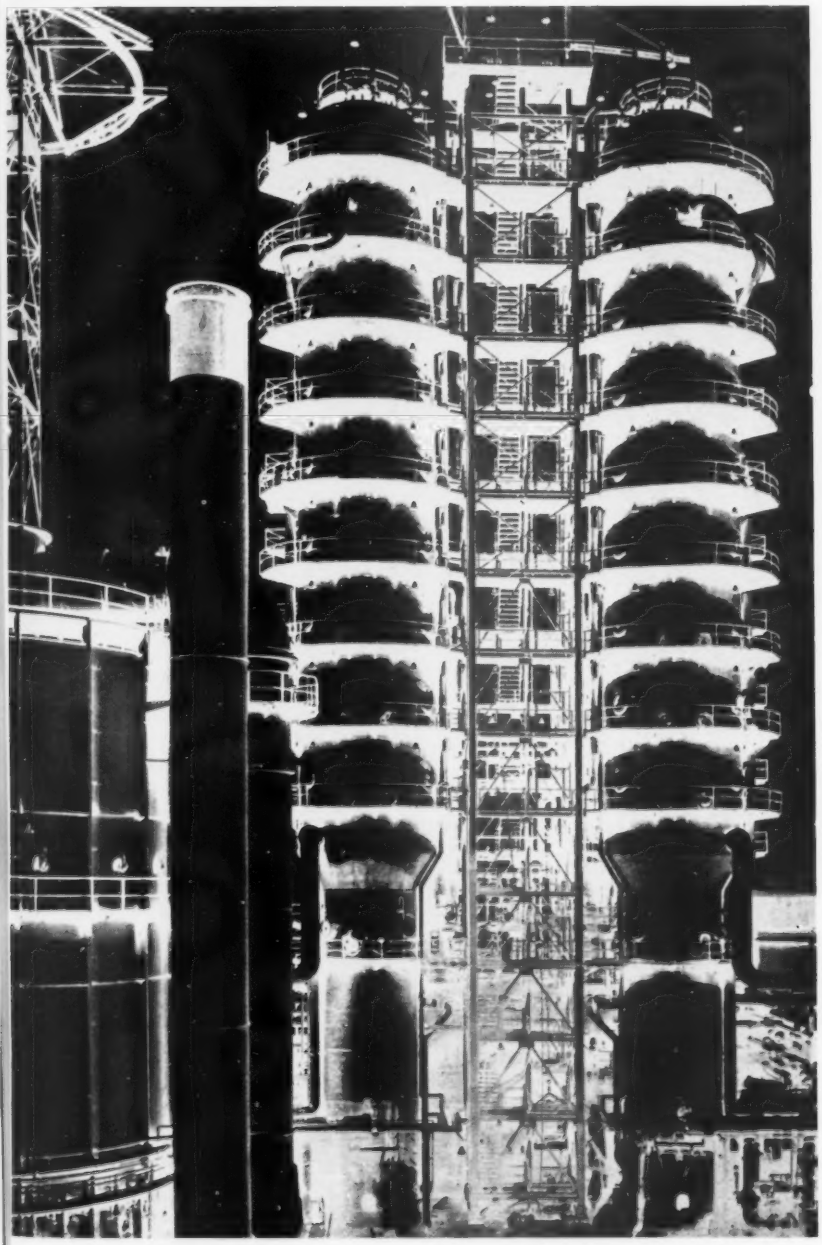

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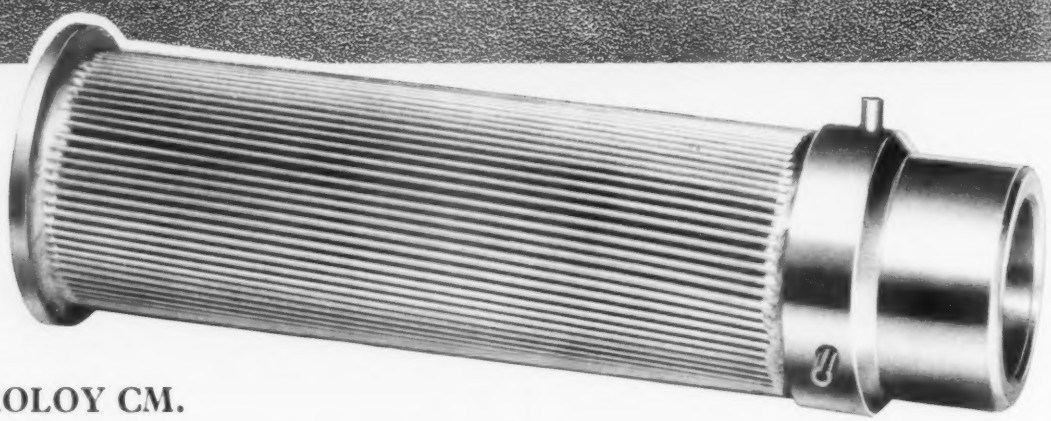

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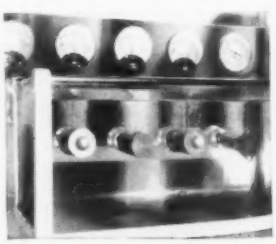
Both filter elements are manufactured in conditions of micro-cleanliness and before despatch are individually checked for performance in the bubble point testing equipment (right).



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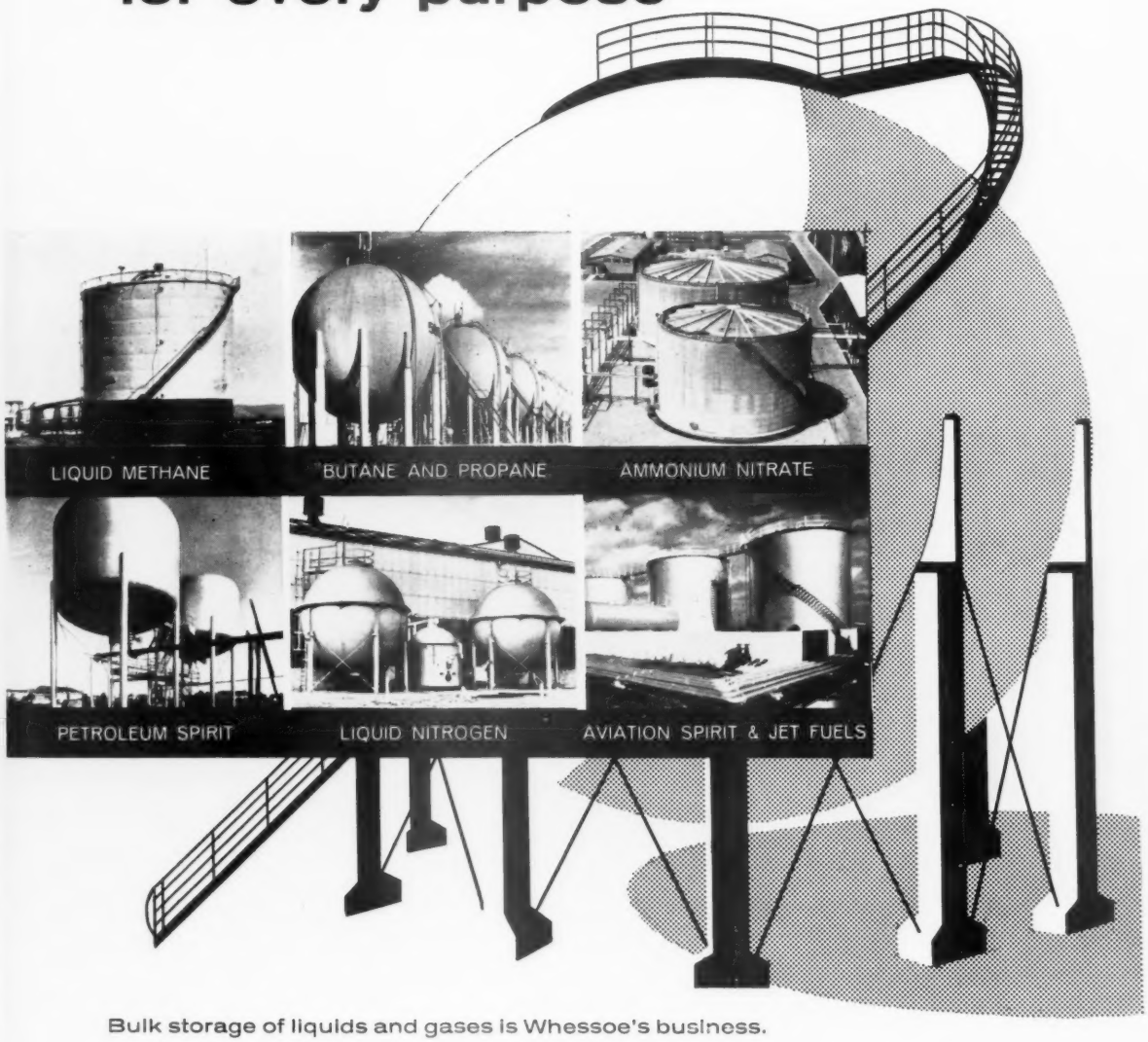

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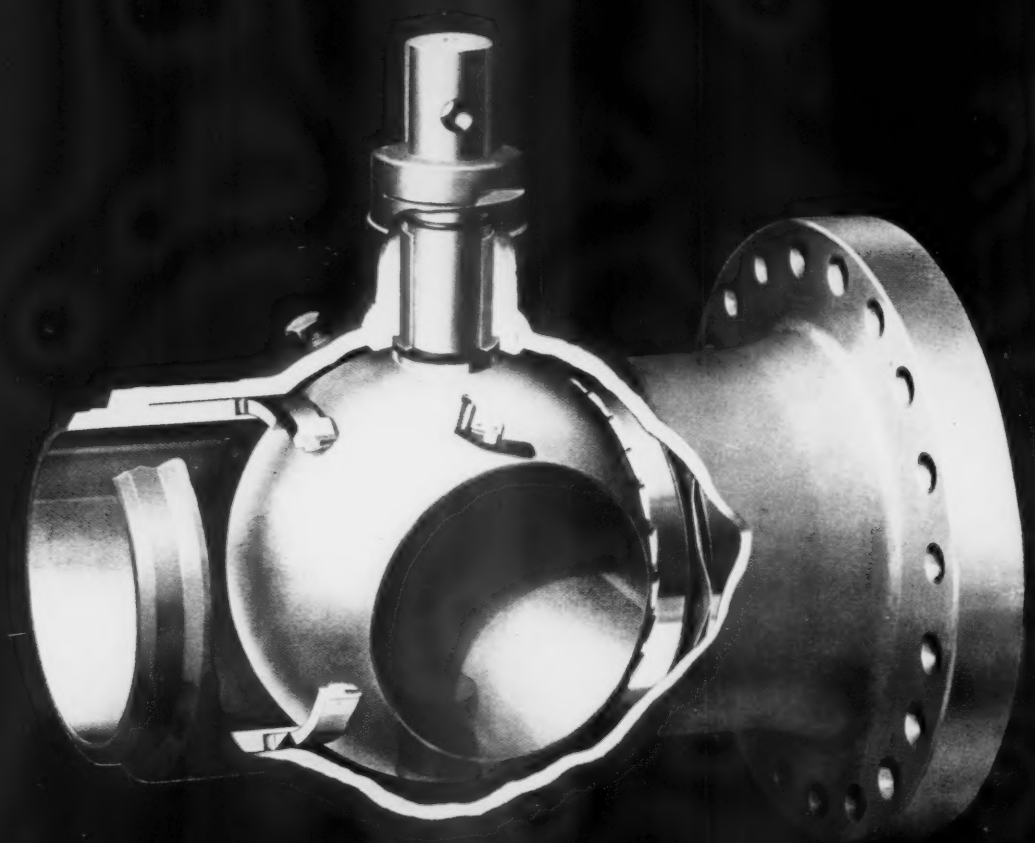

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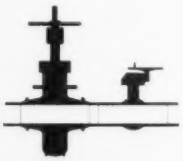

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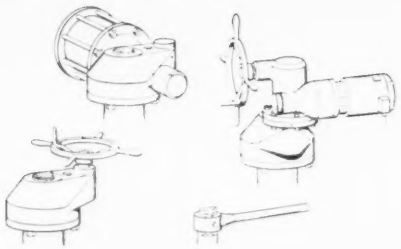

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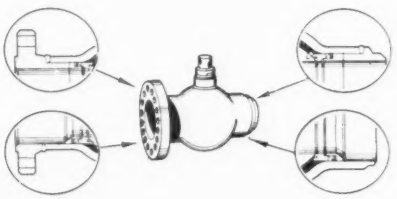
The CAMERON BALL VALVE requires only a fraction of the effort that other valves must have to operate. Much larger valves may be lever operated with ease. When necessary, highly efficient gear operators requiring a minimum of turns and effort are provided. All types of electrical, pneumatic and hydraulic operators manufactured by Cameron are available and special operation problems are solicited. Operators of other manufacture may be installed on request.



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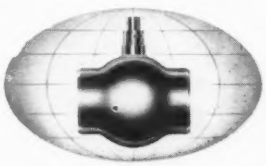

CAMERON BALL VALVES are available and will be manufactured worldwide in five Cameron Plants—France, England, Canada, Mexico and the United States. Processes in each plant follow the same specifications and rigid controls established by the home plant in Houston, Texas.

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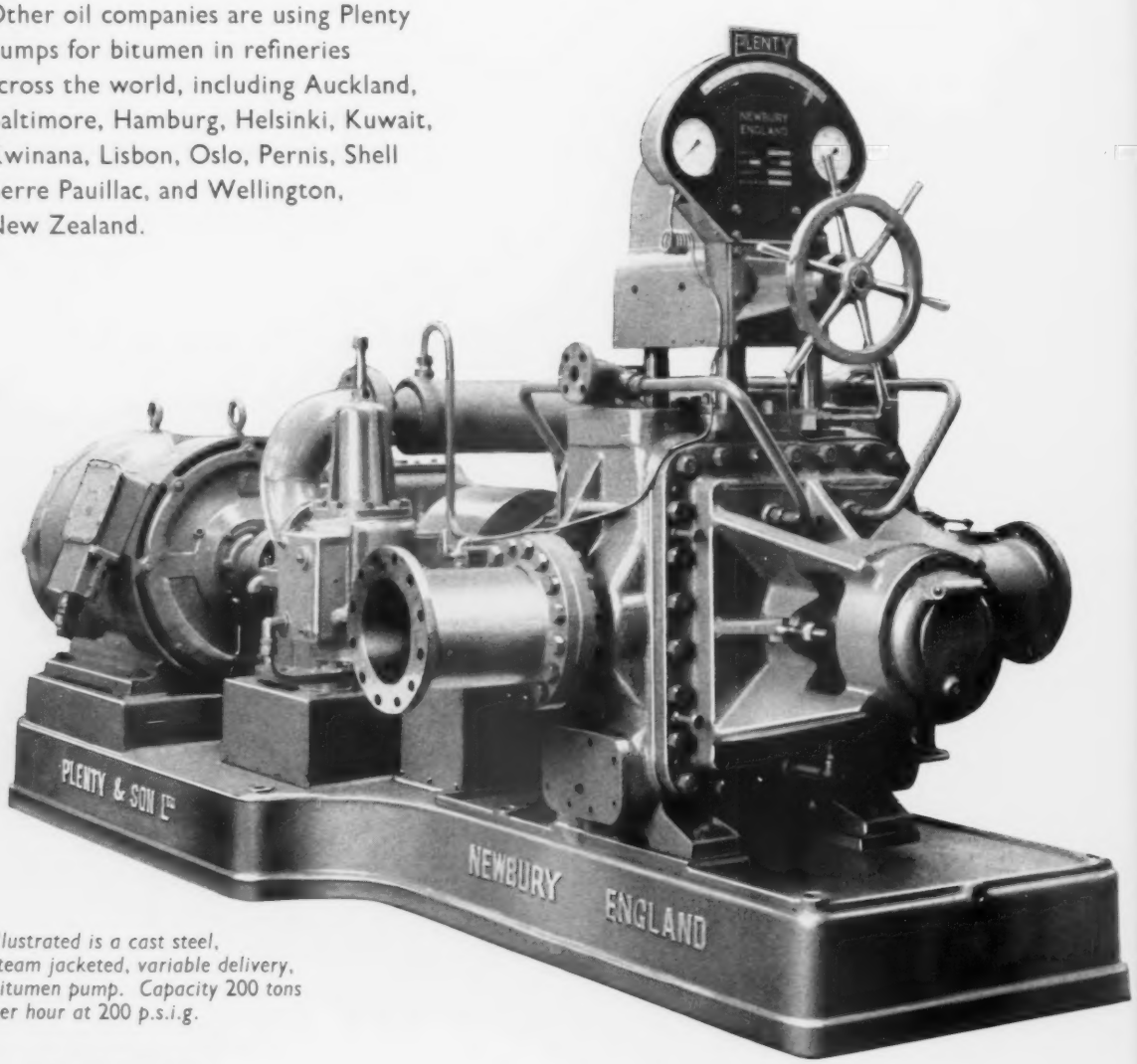

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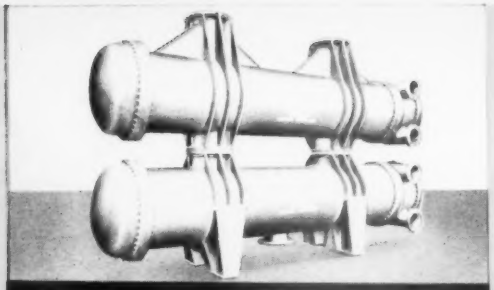

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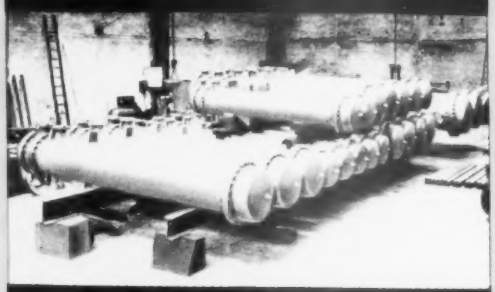

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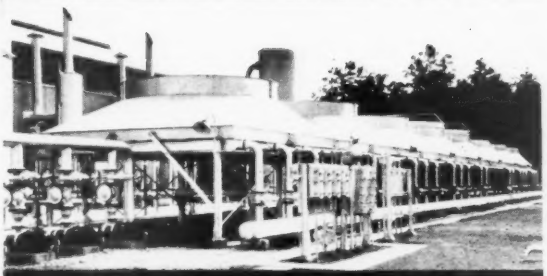

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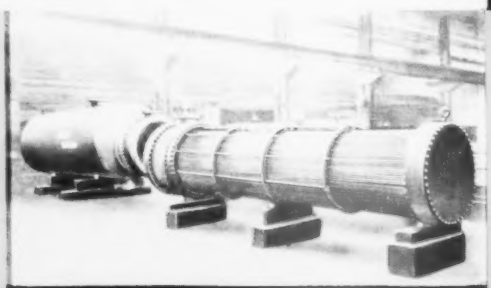

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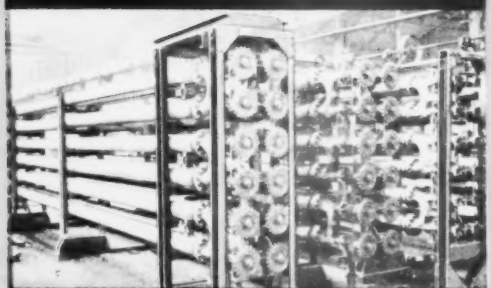

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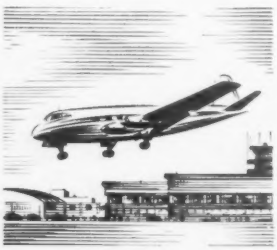

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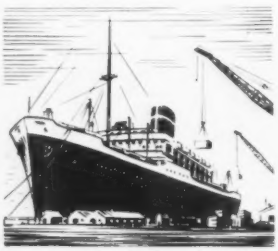

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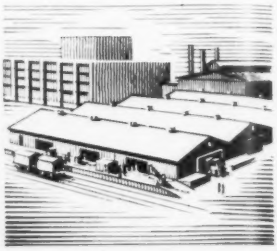

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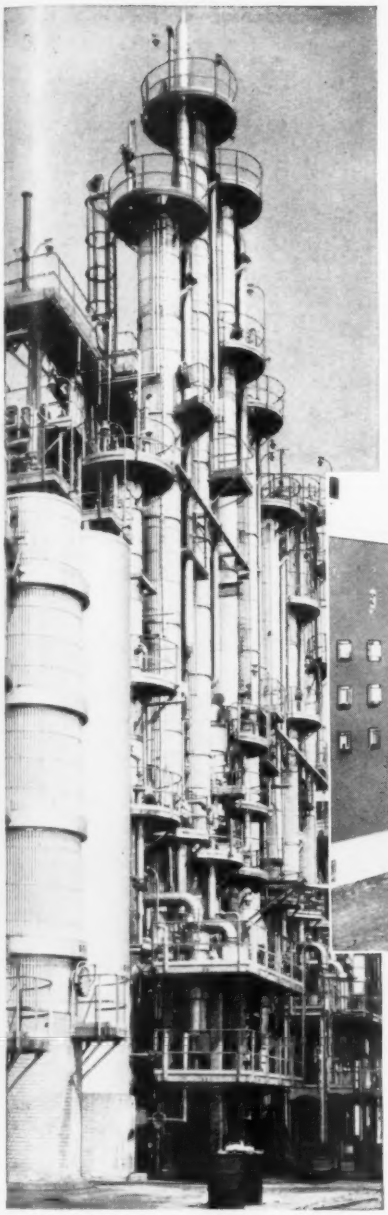

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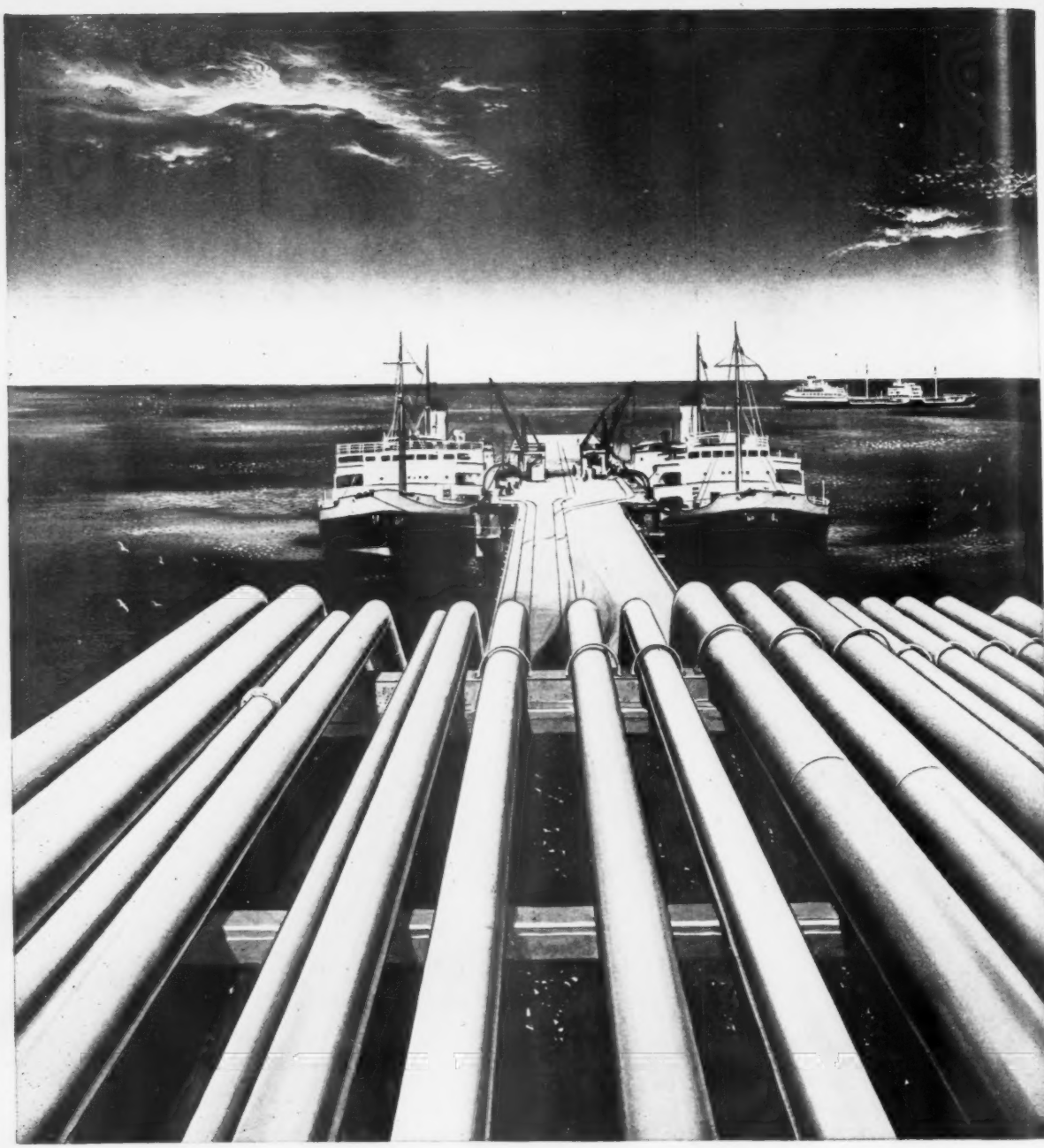

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*An Introduction to the Free-Piston Engine**

By R. M. HOSIE and K. A. TROTH†

Introduction

In 1952 Sir Harry Ricardo wrote in the preface to his work on the high-speed internal combustion engine that the time was about ripe for the appearance of a new and fundamentally better form of internal combustion engine. Coincident with this observation there was commissioned into commercial service the first of just such a new prime mover, the free-piston engine. It is the object of this paper to serve as an introduction to this significant development whose early performance suggests that indeed it may well replace the long-established diesel engine and the still-developing gas turbine in a wide variety of applications in the not-too-distant future.

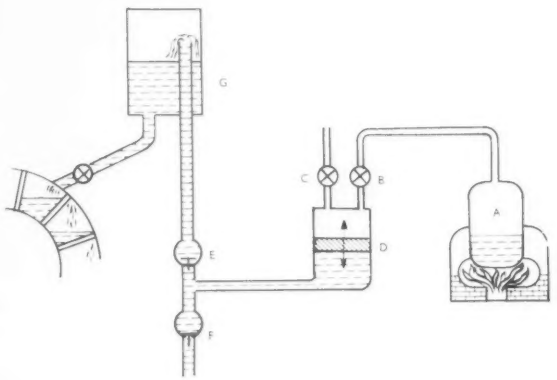
Historical

The conception of the free-piston machine, *i.e.* a machine in which the motion of the pistons is controlled solely by fluid pressures, is not new; indeed the earliest of heat engines were of this type. Probably the first true free-piston machine was Papin's modification of Savery's steam pump in 1705. A diagrammatic arrangement of this engine is shown in Fig. 1

Steam was supplied from boiler A through valve B to the upper half of the pump cylinder D. As the fully floating free piston—it was made of wood—was forced downwards, water was displaced from the lower half of the cylinder through a non-return valve E to a reservoir G. The upper or steam half of cylinder D was then exhausted through valve C when the free piston rose and the lower half was recharged through non-return valve F. The cycle was repeated as necessary.

Fig 1

Papin's free-piston steam pump



As its name suggests, the free-piston machine is not a source of mechanical power; Papin's steam pump supplied water against a head to drive a water wheel which was the true prime mover. Likewise, the present day free-piston machines are not prime movers in themselves but are particular types of reciprocating internal combustion engines which deliver gas under pressure. The "free piston engine" comprises a free-piston gas generator or gasifier supplying high pressure, high temperature gas to a multi-stage expansion turbine where the gas energy is converted into shaft horsepower.

The conception of a heat engine comprising a reciprocating internal combustion engine, whose total output is the energy of its exhaust gases, feeding a rotary prime mover—a turbine—was first recognized by the Swiss engineer, Alfred J. Buchi, who took out a French patent in 1905 on a gas generator/turbine system following his studies of exhaust turbine-pressure charging of diesel engines. In fact, the pressure-charged diesel engine supplying gas to a working turbine would appear to be turbo-charging taken to its logical end; for, as the charging pressure is progressively increased in the exhaust turbo-charged crankshaft engine it becomes possible to take more and more power from the turbine shaft until eventually all the mechanical power can be taken from the shaft of the turbine and none from the crankshaft. Since no power is taken out of the "gas generator" mechanically, no crankshaft is necessary and therefore the power piston and the compressor piston may be directly connected. Such an arrangement was actually designed and run in Britain by Metcalf Dale in 1922, but owing to certain difficulties this development was not continued.

The free-piston engine of today, however, stems from the

* Presented to the IP Stanlow Branch on 18 November 1959.

† "Shell" Research Ltd, Thornton Research Centre.

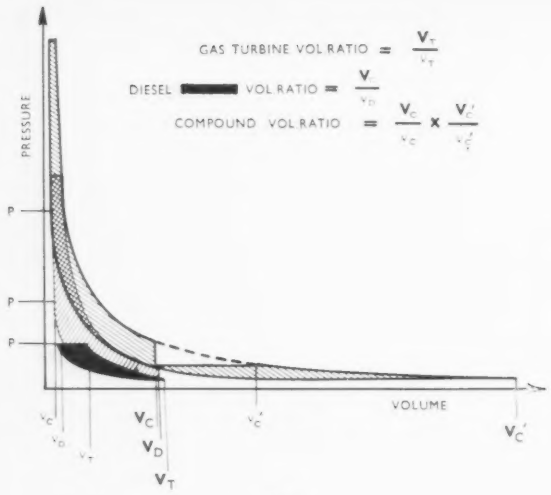


Fig 2

P-V diagrams for gas turbine, diesel, and compound engines

work in France by the Marquis de Pescara, who, when seeking a very light air compressor that would drive the rotor of a helicopter by means of the reaction of air jets, designed a free-piston air compressor which first ran in 1925. As a development of this, the idea of supercharging the power cylinder by the compressor was conceived and led to the free-piston gas generator. In the course of extensive examination of the possibilities of free-piston gas generators in both Europe and America, a number of thermodynamic cycles and construction arrangements have been studied and tested, but of all the proposed designs only one—the Pescara free-piston engine system—has reached a degree of maturity sufficient to be launched on the commercial market. To-day, the total output of all Pescara free-piston engines installed and on order throughout the world exceeds 400,000 hp, and the fields of application include electric power generation, marine propulsion, gas and air compressor drives, rail traction, and fluid pumping.

The Case for the Free-Piston Engine

The attractions of the free-piston engine system can be considered under two broad headings, *viz.*, the thermodynamic appeal, and the practical appeal.

Consider first the thermodynamic appeal. The fundamental question of thermal efficiency is: what greatest fraction of heat is it possible to convert into work? Carnot gave the complete answer to this in 1824 when he showed that maximum work was obtained from a given amount of heat if it could be made to pass from source to receiver through an engine working in a strictly reversible manner. This is impossible of realization and all practical thermodynamic cycles fall appreciably short of Carnot's ideal cycle. It is, however, the continued aim of engine designers to approach maximum efficiency of conversion by adherence to the following principles:

(i) the engine must take in heat at the highest possible temperature.

(ii) the engine must reject heat at the lowest possible temperature,

(iii) the heat losses by radiation and convection must be held to a minimum.

To satisfy the first of these, it is essential that the compression pressure, and thereby the temperature at which the fuel is added, should be as high as possible, *i.e.* the compression ratio must be high. Here is found a very considerable difference between the rotary and reciprocating internal combustion engine. In the gas turbine the compression takes place in a turbo-compressor which in its present state of development will only give a pressure ratio of about 7/1 max., and whose power requirements are supplied by the turbine. In the diesel engine, on the other hand, compression is undertaken directly by the power piston and compression ratios of 15/1 to 20/1 are quite practicable, the actual ratio chosen in any particular case being dependent on considerations of mechanical loading of the engine crankshaft and bearings. In the free-piston engine, which is a special type of compound engine incorporating the main elements of the diesel engine and gas turbine, compression takes place in a piston compressor whose power requirements are derived from the diesel cycle. Since there is no crankshaft in the diesel component it is possible to use compression ratios of the order of up to 60/1 and maximum cylinder or combustion pressures considerably higher than are practicable in conventional diesel engines.

Basically, it is the volumetric expansion ratio which governs the thermal efficiency of the cycle. As shown in Fig 2 combustion in the gas turbine takes place at constant pressure and the expansion ratio is therefore comparatively low. In the diesel engine combustion takes place partly at constant volume and partly at constant pressure, and thus the diesel engine has a much higher expansion ratio. In the compound engine, however, where the high-pressure part of the cycle is done with high efficiency in the diesel component and the low-pressure part in the turbine component which is capable of handling large volumes in a rotary machine of small physical size, the overall expansion ratio is the product of the ratio in each component. In the free-piston engine the whole work of the turbine is available, for in the gas generator the air after compression is supplied with enough heat from combustion of the fuel for the indicated work of the diesel cylinder to be equal to the work of compression plus the friction of the moving parts. It would thus be expected that the thermal efficiency of the free-piston engine would be high; in fact the thermal efficiency of the gas generator is about 43 per cent. This, however, is offset by losses in gas transmission and in the turbine/reduction gear, and thus the overall thermal efficiency of the free-piston engine is just slightly below the figure for the best diesel engine. But with reduction in the internal losses in the free-piston gas generator and improvements in turbine efficiency there is every possibility that the thermal efficiency of the free-piston engine may surpass that of the diesel engine in the future.

Turning now to practical considerations. Unlike the diesel engine there is no vibration from the inertia of the reciprocating masses in the free-piston engine. By the adoption of the symmetrical opposed-piston principle with the masses made as nearly identical as possible, there is virtually no vibration in the gas generator, and accordingly, as in the case of the gas turbine, heavy foundations are not required. However, some qualifications of this claim to no vibration in the free-piston engine must be admitted, for there are other possible sources besides the inertia of the moving parts. The inertia of the exhaust gases, which leave the diesel cylinder at high velocity during blowdown, could cause considerable forces on the gas generator and ducting, and if unsuitable structures are used resonance at certain speeds could cause

considerable vibration. Since the speed range of the free-piston gas generator is limited this source of vibration can be easily avoided. Another source of vibration stems from the pulsations at the air intakes to the compressor cylinders which can cause "panting" of the engine room walls. These air pulsations, however, can be greatly attenuated by suitable designs of air intake casings mounted round the compressor cylinders or by ducting from outside the engine room through damping chambers.

A number of gas generators can be piped together to supply a turbine of any required power. Thus a very wide range of power can be obtained with one size of gas generator. Considerable flexibility in layout is possible in multiple gas generator sets because there are no alignment problems, the only connexion between the gas generators and the turbine being by means of ducts, either flexibly coupled or flexible enough in themselves.

The inherent reliability of the multiple gas generator set is readily apparent, the stopping of one gas generator for any reason resulting in only a fractional reduction in the total available power of the set. Again the provision of one extra generator unit would permit continuous maintenance of the gas generators with maximum availability of the plant in, say, base load power generation.

Owing to the fact that high pressure loads are absorbed by the inertia of the balanced reciprocating masses, and that high-speeds and very high supercharging are inherent features, the weight/power ratio of gas generator machinery is low. This is to some extent offset by the reduction gearing required for the small high-speed turbines. Nevertheless, the power/weight ratio of the free-piston engine is markedly superior to that of the large slow-running diesel engine and the long-life maximum economy design of gas turbine.

For the above reasons, too, the space requirements of free-piston engines are low, an advantage of particular importance in marine propulsion. Further, the various moving assemblies of the two components, generator and turbine, are of necessity relatively compact and lightweight which cannot fail to facilitate maintenance. This is indeed the case in current free-piston engines where the mechanical design is simple and the removal of the moving parts which might require servicing is quick and easy.

As the free-piston gas generator may operate at compression ratios up to 60/1, and with high excess air ratios, it is possible to burn a wide variety of fuels ranging from gasoline to heavy residual fuel. With suitable fuel treatment and injection equipment design the burning of the low-cost heavy grades in the free-piston engine is a very similar task to that successfully achieved in conventional supercharged, slow speed, diesel engines. Again, since the exhaust gases enter the turbine at less than 900 F, there are no problems of turbine blade corrosion or deposit build-up from ash-forming materials such as vanadium as would be the case in the continuous combustion gas turbine, where for maximum thermal efficiency gas inlet temperatures range from 1300°-1500° F.

The Free-Piston Gas Generator

Free-piston gas generators can be divided into two main types, *viz.* inward compressing, and outward compressing, according to which stroke of their operating cycle is used to compress the scavenge air charge to the diesel or power cylinder. It is proposed here to confine considerations of design, operation, and control of these machines to the inward compressing GS34 gas generator, which is the only free-piston gas generator in commercial production at present.

The GS34 design is characterized by its simple unit construction of generally cylindrical form centring round an opposed-piston, two-stroke compression ignition power cylinder. Fig 3 shows the general arrangement with the identical piston assemblies at their extreme limit or outer dead point. A welded steel engine case of cylindrical shape serves as a central support. Two large diameter compressor cylinders, with intake valve support rings, project from either end and are closed by dished ends to form cushion or bounce chambers. The water-jacketed diesel or power cylinder assembly, comprising a scavenge cylinder and an exhaust cylinder bolted to a centre section which carries the fuel injectors and forms the combustion chamber, is located in the centre of the engine case, the annular space outside the water jacket serving as a receiver for the scavenge air. Within this space is an oil-tight housing for a lightweight parallelogram linkage which connects the pistons—this linkage is necessary to eliminate small differential forces on the piston assemblies due to friction, wear, etc. The compressor cylinders are formed on the inner faces of the pistons and deliver air directly into the engine case through automatic valves located in the water-cooled cylinder covers which separate the cylinders from the engine case. The moving parts, *i.e.* piston assemblies, are carried by the surfaces of the diesel and compressor cylinders, and are located axially by a guide tube traversing the whole length of the machine; this tube also serves as a balance pipe connecting the two cushion cylinders. The free-piston principle allows of a particularly simple arrangement to be used for the cooling of the diesel pistons, consisting of a stationary tube mounted on the cushion covers which throws a jet of oil on to the underside of the piston crown. The return is made through a concentric sliding tube attached to the diesel pistons.

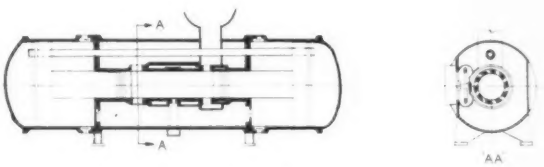


Fig 3

GS34 free-piston gas generator

With a few exceptions all the moving parts of the GS34 unit are served by a total loss system of lubrication employing a forced-feed lubricator mounted externally. This lubricator, comprising a battery of elementary reciprocating pumps, is driven from the piston synchronizing linkage and oil is therefore delivered only when the machine is running. Each engine cylinder, *i.e.* diesel cylinders, compressor cylinders, piston guide tubes, etc., has one or more points of entry for the lubricating oil disposed round its circumference, and generally each point is connected to a lubricator pump by a separate pipe. The remainder of the moving parts, such as the synchronizing gear and fuel pump drive, are lubricated by a pressure circulating system which is also used for the piston cooling supply.

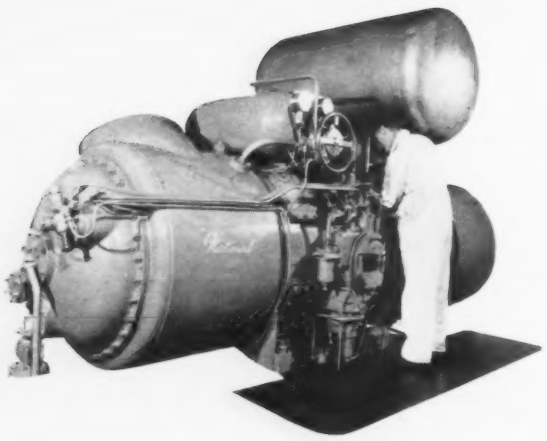


Fig 4

*GS*34 *free-piston gas generator*

The principal dimensions of the GS34 gas generator are as follows:

Diesel cylinder diameter	13·4 in
Compressor cylinder diameter ...	... 35·4 in
Piston stroke at full load ...	... 2 17·4 in
Overall length	... 14 ft
Overall height (incl gas collector)	... 9 ft
Dry weight (incl gas collector)	... 8 tons

Fig 4 shows the control side of a GS34 gas generator mounted in a test house.

The working cycle of the GS34 free-piston gas generator may be followed from Fig 5. When combustion takes place, the gas pressure forces the piston assemblies outwards. During this outward motion the compressors aspirate fresh air through the suction valves and at the same time compression begins in the cushion cylinders. The exhaust ports in the diesel cylinder then uncover and blowdown of the combustion gases takes place. Immediately afterwards the scavenge ports open and compressed air stored in the engine case scavenges the diesel cylinder flowing out to the gas collector to form with the combustion gases a high temperature gas/air mixture. The compression of air in the cushion cylinders brings the piston assemblies to rest at the outer dead point and then drives them inwards. Immediately, the suction valves close and compression of the fresh air charge begins in the compressors. As the pistons continue inwards, first the scavenge ports and then the exhaust ports are covered and compression begins in the diesel cylinders. The pressure in the compressors then reaches the level required for discharge to the engine case, and as the pistons near the end of their stroke fuel is injected at the time when the energy of the pistons has been spent in the compressors and stored in the diesel cylinder. At this, the inner dead point, the cycle begins again.

The fuel injection system of the gas generator consists of a modified "jerk" pump feeding six atomizers or automatic fuel valves which inject the fuel in fan-shaped sprays on the centre line of the diesel cylinder. The pump is actuated by a cam fitted on the axis of the synchronizing linkage, thus coordinating its operation with the motion of the pistons. In contrast with a crankshaft engine, the camshaft does not rotate at a constant speed, and as the pistons approach inner dead point the camshaft is rapidly coming to rest. There is, therefore, insufficient motion to actuate the normal type of jerk pump at the time when the fuel charge is to be injected. This problem has been overcome by pressurizing the fuel charge during the inward movement of the pistons and storing it for release at the appropriate time.

The pistons of the free-piston gas generator are free only in the sense that they are not constrained mechanically, for the synchronizing mechanism previously mentioned does not restrict their motion but merely ensures that it is the same for both sets of moving parts. The motion of these pistons, however, is quite precisely controlled by the gas pressures acting on them and by their own inertia. Each piston assembly may be thought of as a spring-loaded mass as shown in Fig 6, whose frequency of oscillation depends on its inertia and on the stiffness of the pneumatic springs, and whose stroke may be altered by changes on the spring forces. It follows from the analogy of the spring-loaded mass that the frequency of oscillation, or cyclic speed, of a free-piston gas generator is not an independent variable as in a crankshaft engine, but is determined by the effective stiffness of the restoring force. This stiffness is determined by the gas pressures in the various cylinders and has an approximate constant value at any given gas delivery pressure. As the frequency is proportional only to the square root of the stiffness, according to the established formula:

$$\text{Natural frequency} \propto \sqrt{\frac{\text{Stiffness}}{\text{Mass}}}$$

it follows that the cyclic speed of the gas generator is proportional to the square root of the gas delivery pressure.

The gas generator mass flow is increased by raising the amount of air delivered per unit time and by increasing the amount of air delivered per cycle. The amount of air delivered per unit time is proportional to the cyclic speed and thus to the square root of the gas delivery pressure, while the amount of air delivered per cycle is proportional to the suction stroke of the compressor which increases as the outer and inner dead points are increased and decreased respectively. To increase the outer dead point, all that is required is to increase the kinetic energy of the pistons on the outward stroke. This is done by increasing the work done on the pistons in the diesel cylinder, *i.e.* by increasing the amount of fuel injected. Similarly, on the return stroke, in order to reduce the inner dead point which will increase the compression pressure in the diesel cylinder, the work done on the pistons must be increased. This requires an increase in cushion pressure which can be achieved by adding air to the cushion cylinders in a manner to be described later.

Thus, in a free-piston gasifier, both the piston stroke and the compression pressure are variable. In practice, naturally, there are limits. The lower limit of outer dead point of the piston stroke is set by the necessity to ensure that the ports in the diesel cylinder are opened sufficiently to ensure adequate scavenging, while the upper limit depends primarily on the dimensions of the machine, as it would be obviously undesirable to permit an outer dead point too close to the mechanical limit. The maximum limit of compression pressure is controlled by the thermal loading of the central zone of the diesel cylinder, *i.e.* combustion chamber, and also to some extent by considerations of piston ring lubrication.

The effect of the limited range of piston stroke has a very marked effect on the characteristics of the free-piston gas generator as shown in Fig 7. There is obviously a limited range of gas flow at each delivery pressure and in particular it is not practicable to reduce the gas flow below the amount corresponding to the minimum stroke. Accordingly, even at very low delivery pressures when the gas generator is idling, the gas flow is very considerable. When the gas generator is delivering to a turbine, as in the free-piston engine, its delivery of gas will exceed the turbine requirements at low delivery pressures. This follows from the fact that the turbine behaves like a fixed orifice in that as the supply pressure is reduced the gas flow falls progressively. Thus there comes a point in a free-piston engine operation where the gas generator delivery can no longer be reduced to match the turbine consumption, and provision must therefore be made to blow-off to atmosphere.

The power delivered by a free-piston gas generator is expressed as gas horsepower. This is defined as the power available from an adiabatic expansion of the gas down to atmospheric pressure. The gas horsepower is, therefore, proportional to the mass flow, the delivery temperature, and the delivery pressure of the gas. The gas delivery temperature obviously depends on the inlet air temperature and the temperature rise in passing through the gas generator. The temperature rise in the diesel cylinder is dependent on the fuel input which is governed by the delivery pressure. It follows from this that the delivery temperature increases with the delivery pressure. The power output of the GS34 gas generator is controlled by varying the piston stroke, and the combined effect of the above dependent variables, *i.e.* mass flow, temperature, and pressure of delivery, is that the power varies over a wide range for quite a small change of stroke. For example, a drop in power of 75 per cent from full load conditions is produced by a reduction in stroke of only about 20 per cent.

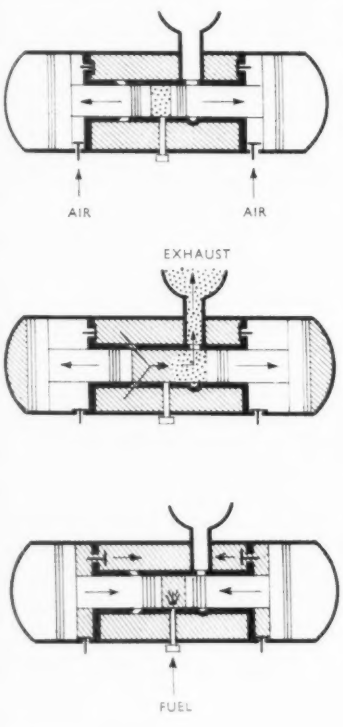


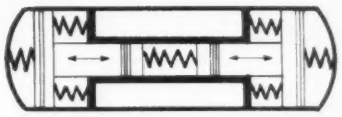
Fig 5

Working cycle of GS34 free-piston gas generator

The operating stability of the gas generator is one of the chief design problems of the free-piston engine. By operating stability is meant the characteristic of the gas generator that ensures the correct return of the pistons towards inner dead point at all working pressures, *i.e.* gas delivery, pressures, and at all strokes; in other words, to maintain sufficient but not excessive compression in the diesel cylinders at all operating conditions. The GS34 gas generator has a large measure of inherent stability as regards variation in stroke for a given delivery pressure. However, in a free-piston engine system the gas generator must be able to run within the limits of the turbine requirements. Thus, as the gas delivery pressure varies the mean pressure in the cushions must be varied to correspond in order to maintain suitable compression pressures in the diesel cylinder. This is achieved by a piston valve controlled by a differential piston balancing the cushion pressure against the scavenge air pressure. This piston valve is known as the cushion control or stabilizer and makes use of the fact that the scavenge air or engine case pressure (P_e) varies very little from the mean while the cushion pressure (P_c) varies over a considerable range throughout the stroke. Thus it is possible at certain times in the cycle to pass air from the engine case to the cushions and vice versa. A diagrammatic arrangement of the stabilizer is shown in Fig 8, the two positions of the piston valve illustrating the charging and discharging of the cushions respectively. The spring adjustment permits the variation over a limited range of the diesel compression pressure, and this provides a very useful means of facilitating starting in very cold ambient temperatures. By increasing the spring load a higher cushion pressure is obtained which reduces the inner dead point and thereby increases the compression pressure. Then as the machine warms up the spring load may be reduced to give normal operation.

Fig 6

"Spring System" of GS34 free-piston gas generator



Starting is effected on the GS34 gas generator by first manoeuvring the pistons out to the starting position near to normal outer dead point by means of a small air-operated piston connected to one of the piston assemblies, and then discharging suddenly a single charge of high pressure air into the cushion cylinders from an external supply. The pistons are thereby thrown together at full speed on the first stroke.

Stopping the GS34 gas generator is simply effected by cutting off the injection of fuel, and this may be done by either over-riding the minimum or idling fuel stop or by releasing the pressure in the delivery chamber of the fuel injection pump.

The timing of the fuel injection is controlled by a simple mechanism sensitive to gas delivery pressure. It will be remembered that with a mechanically-operated pump injection is initiated when the pistons reach a certain position. However, as the inner dead point increases with gas delivery pressure some advance of injection timing is required to maintain a constant interval between the start of injection and inner dead point. Further, as a rise in gas delivery pressure results in an increase in cyclic speed, the injection timing must again be advanced.

The variation in turbine output supplied by one or more gas generators is obtained by varying the quantity of fuel to each generator and thereby varying the mass flow and the pressure of the gas delivered. In this way any loss of efficiency caused by throttling the gases before the turbine is obviated. The quantity of fuel to an engine is controlled either manually or by the turbine governor which transmits a control oil pressure to the individual fuel pump racks of the gas generators. A stop placed between two cams and controlled by the

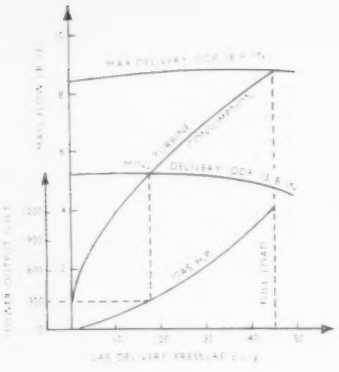


Fig 7

Characteristics of GS34 free-piston gas generator

gas delivery pressure fixes the limits of the stroke of the fuel pump racks, and so adjusts the maximum and minimum quantities of fuel to the load as defined by the gas pressure. As already mentioned the minimum delivery of a gas generator at low loads is considerable, and is more than the turbine can absorb. At such loads therefore it is necessary to discharge the excess gas to atmosphere through a blow-off valve placed between the gas generator and the turbine.

Free-Piston Engine Applications

At the present time the commercial applications for the Pescara free-piston engine system have included electric power generation, marine propulsion, gas and air compressor drives, rail traction, and pumping service with shaft outputs of 1000–13,000 hp. It is not proposed here to review the general applications of this new prime mover, but rather to consider some possible uses of the free-piston engine in the petroleum industry.

The characteristics of the free-piston engine particularly favour its use as a mobile and completely self-contained power plant. Such plants for electric power generation would comprise GS34 gas generators, each mounted complete with auxiliaries, cooling radiators, etc., on a 10-ton vehicle, supplying a turbo-electric generator unit mounted on a similar vehicle. Since the gas generators are completely balanced no heavy foundations are required; thus the individual units of the installation need not be unloaded from the vehicles, it being only necessary to connect up after arrival on site. Transport of the units by air is also a possibility. While such mobile power plants could be used for any land requirements the special application to oil exploration rigs is readily apparent. A free-piston gas turbo-electric generator installation mounted at any convenient point near the derrick could be used with electric motors on the drilling platform for the rotary table and slush pumps. Alternatively, the gas generators together with turbine and gearing could be mounted alongside the platform, the rotary table and pumps being driven in the normal way either by chain or shafting from the turbine shaft. Here the free-piston engine shows to advantage over the diesel engine since the flexibility of drive and the high torque at low or near stalling speed characteristic of the turbine obviate the need for torque converters.

The inherent ability of the free-piston engine to use a wide variety of petroleum fuels has led to considerations of its use in the transportation of petroleum fluids by pipelines. Already, several free-piston engine driven pumping installations, comprising GS34 gas generators and turbine-driven pumps, are in service on the Hassi Messaoud–Bougie pipeline transporting Sahara crude to the Mediterranean coast. As these stations are situated in the desert the fuel used in the free-piston engines is the crude oil actually being pumped through the line. Parallel with this, the use of natural gas as a fuel for the gas generator is under active study for the eventual utilization of the free-piston engine in pumping stations on gas pipelines.

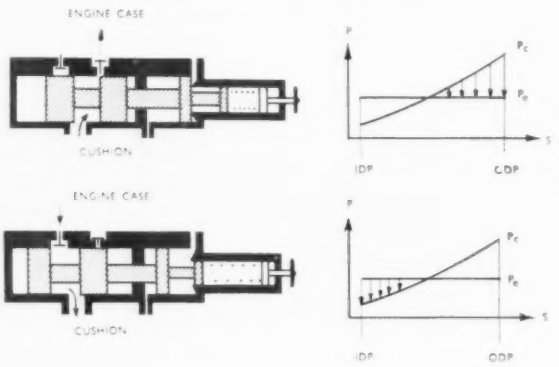
The advantages of installing the main propulsion machinery in the after end of cargo ships has long been appreciated by petroleum tanker operators. Apart from the elimination of the propeller shaft tunnel with the resultant saving in maintenance and the beneficial effect on the deadweight/displacement ratio, the most attractive feature is the midships gain for cargo carrying. The low specific weight, and flexibility of installation due to light foundations and lack of vibration, of the free-piston engine offer considerable possibilities in better space utilization in the awkwardly-shaped machinery compartments placed right aft. Again, the small space requirements of the free-piston engine compared with either the large direct-drive diesel or the long-life gas turbine indicate further probable gains in cargo capacity by reduction in the lengths of engine rooms required.

Multiple gas generator/turbine sets may also be used for the continuous supply of power in refineries and chemical plants where 100 per cent availability is essential for long periods of time. Reliability is achieved by the addition of standby gas generators which can be started up very rapidly and brought into operation while one of the other machines is shut down for maintenance. Where several turbine-driven pumps, compressors, or electric generators are sited in the same plant, the use of a ring main arrangement of gas piping facilitates the reduction of separate standby gasifiers.

There would appear, too, several advantages to be obtained from compounding the free-piston gas generator/turbine plant with a steam turbine plant, either for large-scale electric power generation or the propulsion of supertankers. The basic conception of such a plant would be to use in the main steam boiler the heat rejected in the free-piston engine exhaust, or alternatively exhaust the gas generators directly into a high pressure *Velox* type boiler, the exhaust from this boiler being then expanded in a gas turbine coupled to the main steam turbines. It has been calculated that the overall thermal efficiency of such a combined plant would be about 34 per cent, compared with some 28 per cent for a pure steam plant.

Fig 8

Diagrams of cushion control operation



Finally, free-piston gas generators have been proposed as a source of high pressure, high temperature air for industrial purposes. One application suggested is the rejuvenation of static oilfields by forcing high temperature-high pressure gas into them to fluidize the viscous oils trapped in the sands and thus make additional recovery of oil possible.

Conclusion

It is axiomatic that in every age the newcomer in its raw and undeveloped state is invariably pitted against the champion of the older school and challenged to defeat it in the first round. That, in only one decade since the first commercial installation was commissioned, a number of widely different free-piston engine applications have been put into service and have been followed by a marked increase in orders for this type of machinery, indicates that the free-piston engine can now be considered as a practical alternative to other types of prime mover. It remains to be seen with what speed and to what extent and for what applications free-piston engines will supplant conventional engines.

Acknowledgments

The authors would like to thank the directors of "Shell" Research Ltd for permission to publish this paper.

* * *

Around the Branches

ABADAN, BAHRAIN, ESSEX, FAWLEY, KUWAIT, LONDON, NORTHERN, SCOTTISH, SOUTH-EASTERN, SOUTH WALES, STANLOW, TRINIDAD, YORKSHIRE

Trinidad Branch

Ammonium Sulphate and Urea from Natural Gas

Dr A. R. Hale of Federation Chemicals Ltd, a subsidiary of W. R. Grace & Co., New York, presented a paper on "The Manufacture of Ammonium Sulphate and Urea from Natural Gas" on 27 May. The Federation Chemicals plant at Point Lisas for the manufacture of ammonium sulphate and urea from natural gas is the first of its kind in the West Indies, and was put on stream in November 1959. In an extremely interesting and well-illustrated talk Dr Hale outlined how the natural gas is combined with steam and air and converted by suitable temperature and pressures in the presence of catalysts to anhydrous ammonia, with carbon dioxide as a by-product. Ammonia and carbon dioxide are subsequently reacted together to produce urea. Sulphuric acid is also produced from sulphur at the plant, of which 70 per cent is imported, the remainder being derived locally from crude refinery processing (Klaus kiln) at Point-a-Pierre. The simple reaction between ammonia and sulphuric acid produces the ammonium sulphate fertilizer.

The plant at Pt Lisas was subsequently visited by members of the Branch on 11 June, which enabled them to see at first hand the processes and equipment described by Dr Hale in his talk. The plant currently processes 4 million cu ft of natural gas per day to produce 240 tons of ammonium sulphate and 70 tons of urea per day, which are exported to South American and West Indies markets. In the process the plant also produces 180 tons of acid and 100 short tons of ammonia per day.

Tea and cakes provided a welcome refreshment at the end of the tour, and Branch members were deeply appreciative of the courtesies extended by the management of Federation Chemicals Ltd and of the very instructive efforts of Dr Hale.

Film Show

On 24 June some 50 members and guests attended a film show at which four films were shown. The films, which proved most enlightening, were provided by courtesy of Shell Trinidad Ltd and covered a fairly wide field. The subject of the films were palaeontology, Schlieren photography, the fight against microbial life and disease by the World Health Organization, and the motor rally for the Coupe des Alpes in 1958.

IP ECONOMICS AND OPERATIONS GROUP

This Group is open to all members of the Institute who wish to take part in discussions on petroleum economics, distribution, transport, and storage. The only formality necessary is to notify E. Herbert, at the Institute's office. Members of the Group are encouraged to invite guests who may be interested in any of the discussions.

The programme for the 1960–61 session is as follows:—

1960	
13 Oct.	**Administrative and Supply Problems in Developing a New Area.** P. Wainwright and J. B. Howard (*British Petroleum Co. Ltd*). (Joint meeting with the Exploration and Production Group).
10 Nov.	**Oil and Rail Transport.** D. L. Munby (*Nuffield College*).
8 Dec.	**European Organizations Affecting the Oil Industry.** J. Ornstein.
1961	
12 Jan.	**The Future in House Heating.** R. Eves (*Consultant Architect*).
2 Feb.	**The Location of Refineries.** Dr P. H. Frankel and W. L. Newton (*Petroleum Economics Ltd*).
9 Mar.	**The Growth of Road Traffic and Motor Fuel Consumption.** Dr R. J. Smeed (*DSIR*).
13 Apr.	**A Review of the Year.** D. Ovens (*Gulf Eastern Co.*).

Personal Notes

Shell International Petroleum Company Ltd has announced the appointment of **E. A. Higgins, J. F. Sinclair,** and **W. F. G. L. Starrenburg,** to the board of the Company.

Dr M. J. Gattiker has been appointed to the board of Bataafse Internationale Petroleum Mij NV.

Mr Higgins joined the Group in 1927, and has served in Venezuela and Colombia. In 1959 he was appointed supply and planning co-ordinator in Shell International.

Mr Sinclair joined the Group in 1928 and served in India from 1929 to 1957 (apart from war service). He was appointed regional co-ordinator—oil, East and Australasia, in Shell International in 1959.

Mr Starrenburg, who joined the Group in 1932, served in Venezuela for many years and was appointed exploration and production co-ordinator in BIPM in 1959, a post which he has relinquished to become regional co-ordinator—oil, Caribbean, Central and South America, in Shell International.

Dr Gattiker joined the Group in 1929, and served in Sumatra, Curacao, and New York, and afterwards in The Hague. In 1959 he was appointed manufacturing co-ordinator —oil in B'PM.

The following additional directors have been elected to the board of Esso Research Ltd: **Thomas R. Bird,** B.Sc., F.R.I.C. F.Inst.Pet.; **Franklin O. Canfeld,** A.B., L.L.B.; and **Kenneth C. Hunt,** B.Sc., A.C.G.I., F.Inst.Pet.

Mr Bird joined the Anglo-American Oil Co. Ltd in 1945. He became general manager of Esso Development Co. Ltd. (now Esso Research Ltd) in 1952. Educated at Trinity Academy, Edinburgh, and Heriot-Watt College, he became deputy director of scientific research for the Inter-Service Research Bureau in 1940, and during 1942–45 was head of the American Technical Mission of the Bureau.

He was awarded the U.S. Legion of Merit (degree of officer) for exceptionally meritorious conduct during the war.

Mr Canfield joined the Production Department of Standard Oil Company (New Jersey) in 1946 as contact with Europe and North Africa. At present he is the SONJ representative for France, Benelux, Austria, Germany, Italy, and Switzerland. He graduated from Harvard College and Columbia Law School, being admitted to the New York Bar in 1936.

Mr Hunt joined the Anglo-American Oil Company in 1937. Appointed manager of Technical Sales Department of Esso Petroleum in 1950, he went to Esso Development Co. Ltd in 1954. Educated at Christ's Hospital and The City and Guilds Engineering College, he spent five years in the automotive industry and two years on development and design in the aircraft industry.

Each of the new directors retain their present responsibilities.

John Oriel, C.B.E., M.C., M.A., B.Sc., F.R.I.C., M.I.Chem.E., Hon.F.Inst.Pet., now an adviser on staff matters to the Shell International Petroleum Co. Ltd, and a member of the Council of the Institute from 1949 to 1956, has been made an Extraordinary Fellow of the new Churchill College of Cambridge University. His duties will be those of a non-teaching Fellow, concerned with the developments and activities which fall to a member of the governing body.

J. F. H. Davies, M.B.E., A.C.A., M.Inst.Pet., and **C. H. W. Smith,** general managers of Markets Department and Supply and Development Department respectively, have been appointed directors of BP Trading Ltd.

H. L. C. Holliday

The manager of the Employee Relations Department of Mobil Oil Co. Ltd, **H. L. C. Holliday,** M.Inst.Pet., has accepted an appointment with Mobil International Oil Company as regional employee relations adviser—foreign areas, in its Employee Relations Department in New York. **E. H. P. Bancroft,** at present manager of the Retail Department, has been appointed to succeed Mr Holliday. **G. N. P. Edwards** becomes the new manager of Retail Department.

Mr Holliday joined the Company as a trainee in 1930, serving on the sales side, and becoming assistant to the sales manager in 1939. He was appointed employee relations manager in 1948. Mr Bancroft also joined Mobil in 1930, and held a series of appointments before becoming advertising manager in 1950. He was appointed manager of the Retail Department in 1958. Mr Edwards has been district sales manager in the Midland Retail Division in Birmingham since 1956. He first joined the Company in 1937, and in 1939 he took charge of the Company's stores at Brookland Race Track. In 1946 he joined the Engine Builders Department before becoming competitions manager for the Company's racing interests in 1948.

E. H. P. Bancroft

G. N. P. Edwards

Dr Robert Albert Ernest Galley, who has been director of the Tropical Products Institute in the U.K. since 1953, has been appointed to succeed **Dr J. E. Hardy,** F.Inst.Pet., as manager and director of research of the Woodstock Agricultural Research Centre of "Shell" Research Ltd.

Dr Galley was educated at Colfe's Grammar School, Kent, and qualified in chemistry at the Imperial College, London. He was awarded a Ph.D. in 1932 for his thesis on the hydrogenation of conjugated compounds, and has had experience in industrial textile research associations and government laboratories.

A member of the World Health Organization Expert Panel on pesticides since 1949, Dr Galley has also served on the scientific secretariat of the Office of the Lord President of the Council, and on numerous government and scientific society committees.

Dr Hardy, who became manager of Woodstock in 1950, will shortly be taking up an appointment with Shell International Chemical Company.

Michael Hubbard, F.Inst.Pet., has retired from the British Petroleum Co. Ltd after 36 years service with the Group. We understand, however, that he is not completely severing his association with the industry and will be doing a limited amount of consultancy work from his home in Kent.

J. M. Storey, C.B.E., has taken up office as chairman of the Council of British Manufacturers of Petroleum Equipment in place of **G. H. Thorne,** who becomes immediate past chairman and chairman of British Oil Equipment Credits Ltd.

N. H. Birdseye has been re-elected as hon. treasurer. **Hector Walker, L. S. Dawson,** F.Inst.Pet., and **F. R. Newman** were re-elected, and **J. Neill-Thompson** and **G. C. Fairbanks** elected to the Executive Committee.

T. L. Bonstow, F.Inst.Pet., technical consultant to the Council, has retired after 18 years service to the Council which he helped to create.

The Castrol Group announces the appointment of there new directors to the board of their subsidiary company, Edwin Cooper & Company Ltd.

They are **J. Romney,** B.Sc., A.R.I.C., F.Inst.Pet., **N. E. F. Hitchcock,** B.Sc., M.Inst.Pet., and **G. H. J. Simmons,** F.Inst.Pet., all senior executives of the Castrol Research and Technical Departments.

The Gas Council announces the appointment of **Denis E. Rooke,** B.Sc., (Eng.), A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.GasE., as development engineer to take charge of the new Development and Planning Section which the Council is establishing.

Mr Rooke is at present development engineer of the South Eastern Gas Board, a position he has held since January 1959.

In 1957 he was seconded to the North Thames Gas Board for investigation work into liquid methane, and a year later went to the U.S.A. as Gas Council representative in connexion with its trial importation. He was one of the technical team which sailed in the *Methane Pioneer* on its first trial voyage.

H. H. Ballard, M.Inst.Pet., Liverpool representative of the Marine Division of Wakefield-Dick Oils Ltd, has retired.

Joining Wakefields in 1919 as an industrial oils representative, for the past 14 years he has been concerned exclusively with Wakefield-Dick's marine business in Liverpool. He is a past chairman of the Northern branch of the Institute.

At a short ceremony at Castrol House, London, recently, W. F. List, assistant managing director of the Wakefield Group, presented Mr Ballard with a silver cigarette box, a gift of the directors. J. S. Rolph, director and general manager of the Marine Division, presented a cheque and a scroll from Hori Ballard's colleagues in the Division.

Mr Ballard being presented with a cigarette box by W. F. List (right)

P. H. Cripps

The Industrial Division of Wakefield-Dick Industrial Oils Ltd has appointed **P. H. Cripps** as its regional sales manager for London and the Home Counties.

Peter Cripps joined Wakefield-Dick in 1947, and was appointed a representative in the London area in 1954.

K. P. H. Jeens, A.M.I.Mech.E., A.F.Inst.Pet., has been appointed manager, Oil Industries Department, of Worthington-Simpson Ltd.

He was until recently with Stone & Webster Engineering Ltd where, for the last six years, he was pump and compressor engineer.

Shell Chemical Co. Ltd announces the retirement of **L. G. J. Engle,** manager of its Southern Sales Region.

Mr Engle originally joined the Shell Group in 1922, and was engaged on marketing and marine aspects of the Company's business before transferring to the chemical side in 1947. Before being appointed regional manager in 1955, he was in charge of detergent sales in southern England.

M. B. Creed, who is appointed as his successor, joined the Shell Petroleum Company in 1938 and transferred to the chemical side of the Group's activities in 1948. In 1954 he was appointed chemical sales manager in the London area. Following expansion of the Company's business, he became the regional sales manager for Solvents and Resins, a post he has held since 1957.

J. Martin

John Martin has been appointed to the board of Mather & Platt Ltd as head of the Pump Department. For the last ten years he has been the managing director of Mather & Platt (S.A.) (Pty) Ltd, and for sixteen years prior to 1949 he was on the staff of the London office of Mather & Platt Ltd.

F. K. Farquharson has been appointed manager of Shell-Mex and B.P.'s Motor Department in succession to **C. H. Selley,** M.I.Mech.E., who retired in June after 38 years' service.

Mr Farquharson joined Shell-Mex and B.P. Ltd in 1938 as a motor engineer attached to head office Motor Department, and subsequently held similar appointments in Liverpool, Manchester, and London, returning to head office in 1950. In 1952 he was appointed motor engineer of Scottish Oils and Shell-Mex Ltd and aviation manager four years later. In 1958 he was promoted to branch manager, Darlington, a position he relinquished upon his present appointment.

We regret to announce that **J. M. Rimington,** managing director of the Chemical Division of the Distillers Co. Ltd until 1 April 1960, died on 19 June.

Mr Rimington was one of the original employees of British Industrial Solvents Ltd, the first large-scale DCL chemical venture, from the time of its formation in 1929.

Dr G. L. J. Bailey has relinquished his position as superintendent of Mond Nickel Co's Development and Research Laboratory in Birmingham, and will transfer to London to become manager of research.

E. J. Bradbury succeeds Dr Bailey as laboratory superintendent.

A. Stephens has rejoined Honeywell Controls Ltd as senior flow engineer at the Company's head office. Mr Stephens' previous experience includes service with Humphreys and Glasgow Ltd on the Chesterfield underground gasification project, instrumentation contracts engineer with Honeywell Controls, and four years apprenticeship with the Ministry of Supply.

R. W. H. Vivian has been appointed to specialize on application engineering of electric miniature instrumentation, at Honeywell Controls Ltd.

Marine and Remote Centre Oil Installations Ltd (MARCOIL) announces that **Colonel Robert Adeane** has taken over the chairmanship from **W. Wallace,** M.I.C.E., M.Am.Soc.C.E., F.Inst.P., who will continue as managing director, to devote more time to the company's increasing technical activities.

T. C. B. Williams has been elected an additional director, and **A. J. Hobson** has been appointed secretary.

Among the recipients of the 1960 Distinguished Achievement Medals awarded by the Colorado School of Mines were **Robert C. Earlougher,** petroleum engineer, president of Earlougher Engineering Inc, Tulsa; **Vernon L. Mattson,** manager of mines and milling, Kerr-McGee Oil Industries Inc; and **Ben F. Zwick,** manager of the oil and gas department, the Chemical Bank—New York Trust Co., New York City.

The silver medal is the highest honour which the School may bestow on an alumnus, and is equivalent to the honorary doctorate.

ASTM AWARDS OF MERIT

Among the nineteen who received ASTM Awards of Merit during the 63rd Annual Meeting of the Society in Atlantic City were:

Charles M. Gambrill, analytical co-ordinator, Research Laboratories, Ethyl Corporation, Detroit. The award was in recognition of long active participation in ASTM activities, notably in Committee D-2 on Petroleum Products and Lubricants, and for administrative and district work.

Robert R. Thurston, consultant and retired assistant manager, Technical Service Division of Research and Technical Department, Texaco Inc. For generous contribution of knowledge to Committee D-8 on Bituminous Materials for Roofing, Waterproofing, etc., and in other technical committees.

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DIESEL FUEL PANEL CHAIRMAN RETIRES

Panel ST-F-2 (Engine Tests of Diesel Fuels) interrupted their meeting on 21 June for this photograph. K. Arter of Esso Research Ltd was in the chair for the last time, after holding this office for 15 years. His association with high-speed diesel engines began with London's first diesel bus. His predecessor as Panel chairman was the late R. H. Stansfield, whose pioneer work before the war laid the foundations for the test procedures currently specified in IP Method 41. The new chairman is P. G. Pigneguy of Shell Central Laboratories.

The photo shows: (*Standing*) D. R. Bailey (*"Shell" Research Ltd*), J. Thompson (*Admiralty*), W. Fitzgerald (*Esso Petroleum Co. Ltd*), Dr B. Whipp (*Imperial Chemical Industries Ltd*), P. F. Whelan (*British Internal Combustion Engine Research Association*), P. R. Carpenter (*Mobil Oil Co. Ltd*), L. M. Cassidy (*Esso Research Ltd*), S. A. Flory (*Regent Oil Co. Ltd*); (*Seated*) R. R. S. Maidstone (*Imperial Chemical Industries Ltd*), K. T. Arter (*Esso Research Ltd*), P. G. Pigneguy (*Shell International Petroleum Co. Ltd*), J. K. Lock (*British Petroleum Co. Ltd*).

PROFITS AND PETROLEUM REFINING

Some interesting remarks on the subject of the economics of refining were contained in a recent speech by the chairman of the American Petroleum Institute, M. J. Rathbone (also president of the Standard Oil Company (New Jersey)), to the API Division of Refining, at its mid-year meeting in Detroit. His subject was "Profits as a Prime Product."

It was said that whilst a great many changes and improvements had been made in the technical side of refining, practically no changes seemed to have occurred in the way in which the economic or business side of refining was regarded. "We still seem to run our refineries as a tool to convert crude oil into products, with apparently no one really being responsible for determining whether all the products are needed or whether they can be sold at a profit."

To-day there was substantial surplus capacity in crude production, in transportation, and in refining capacity. There had been excessive stocks of crude oil and products for several years, and marketing competition for a larger piece of a smaller market increase had been very keen. In addition, the great expansion in low-cost transportation facilities for crude and products resulting in every refinery's trading area becoming progressively larger and competitive overlaps becoming even more pronounced, had taken place in the postwar period. Again, technology now made it possible for a smaller-sized refinery to match the performance of a big one in efficiency, in cost, and in ability to turn out high quality products. All these things had sharpened and widened competition.

Virtually nothing had been done by refiners to adapt themselves to the new situation whereby overall company profits could no longer support the sort of poor relation which refining had always been—taking up too much of capital budgets and seldom making money. In the last two or three years refiners had successfully cut costs and improved efficiency, it was true, but it seemed ironical that the savings thus realized were being used, in effect, to feed, aggravate, and add to the very circumstances which made the economy efforts so necessary in the first place.

"We have continued to stress volume, apparently with complete disregard for the economics of the situation we face. No industry can be immune to the impact of supply and demand, to the pressures of prices, to the forces of competition, and other economic factors.

"To remain wedded to volume alone as a criterion of performance is sheer folly. The 'incremental throughput' philosophy has spread like a virus throughout our industry. It has coloured our judgment and weakened our perspective. The total market demand for our products at any given time is relatively inflexible, and surplus and weak prices do little to create any substantial increase in demand. 'Incremental throughput' doesn't change this fact.

"Another example of ineffective business performance was said to be the quality story. In the past fifteen years product quality had been improved repeatedly and at a very substantial cost. But there had been no corresponding increase in realizations, for as automobile manufacturers raised compression ratios, octane numbers went up, and refiners invested heavily year after year to meet the trend. Instead of realizing that with a very diverse car population a new approach was needed in marketing, the industry stayed wedded to a two-grade gasoline system which gave away unneeded quality to thousands of motorists and made recovery of added costs of octane improvements almost impossible. I think it is a fact that the motoring public would have been served just as well, and perhaps even better, had the industry adopted multiple grades a lot sooner. And refiners would have been saved millions of dollars".

Mr Rathbone remarked that it had been reported recently that the automobile manufacturers wanted the oil industry to increase the octane rating for regular gasoline, in order to satisfy advertising claims made for the new economy engines.

"If that is so, some serious problems are raised for the oil industry. In the first place, an octane hike in regular gasoline would be wasteful. The large majority of motorists using this grade would have quality they could not use, just to please those drivers who should be buying premium gasoline anyway! The cost of even a small increase in octane number would run to millions of dollars in the next few years. In view of the current market situation, it would be difficult or impossible to recover this added cost. It would have to be absorbed by the oil industry and, in all likelihood, we would experience further losses when some of our present premium customers switched back to upgraded regular".

In conclusion Mr Rathbone presented for consideration some suggestions to help alleviate the problem.

"I think that refiners should study and gain a better understanding of oil economics—and then make real use of that knowledge. Refiners must orient their thinking to the demands of the market—it should not stop at the refinery gates. We must know what it costs to make high-quality products and judge correctly the prospects for recovering added costs. We must understand crude values better. Quicker and more realistic adjustment of refining operations to seasonal demand factors is essential, especially when marked changes from normal weather occur. Every refinery should be run with a profit and loss statement, and the looks of the profit and loss statement should be as important—if not more so—as the unit cost statement, in judging the effectiveness of refinery operations and refinery managements.

"The second thing we can do is to work on ways to expand demand for oil products. If every car travelled another 100 miles a year, U.S. consumption of gasoline would rise one per cent. This means only another two to three hours of driving each year, or less than four more minutes a week behind the wheel. Yet one per cent is equal to about 10 million brl/year."

What was said to be perhaps even more important was finding new uses for oil products. In the past, oilmen had relied on inventive people outside the industry to develop uses for oil products. It was time the oil industry did something really substantial along these lines.

As examples of such uses the work of Jersey Standard in using asphalt to permit the growth of farm crops in semi-arid areas of the world; the substitution of fuel oil or gas for coal or coke in the metallurgical industry; and the hydrocarbon fuel cell, were quoted. The use of oil for air conditioners, water heaters, driers, and other household uses was another field of study which appeared.

These attempts, it was said, barely scratched the surface. There were countless new uses which remained to be found. It was believed, for example, that plastics derived from oil would someday find important structural uses in buildings and houses, whilst some scientists felt that crude oil components might possibly be converted into foodstuffs.

The World Oil Industry in 1959

The 1959 issue of The British Petroleum Company's annual booklet *Statistical Review of the World Oil Industry* has now been published. This perennially-useful publication of salient world oil statistics has a similar scope to its predecessors, and in addition has had its value considerably enhanced in the present edition by the inclusion of all statistics in barrels a day (as well as in tons a year as formerly). Other additions to the usual range of statistics are percentage graphs of end-use product demand in U.S.A. and Europe in 1959; a more detailed breakdown of international oil trade by major areas; European oil supply and demand by EEC and EFTA trading areas; more comprehensive statistics on world refining; and new sections on production and reserves, consumption and trade, refining and tankers, covering the last 10 years with comparable data for 1938; it concludes with basic tables of conversion factors.

The commentary is summarized as follows.

Reserves

World published proven oil reserves showed about the same increase as production, to reach 39,870 million tons at year-end. Some two-thirds of the net increase in reserves was in the main producing areas. The Middle East once again was the area with the largest increase, its rise of 970 million tons to a total of 24,345 million at the end of 1959 being considerably more than was achieved a year ago. In spite of the contraction in much of the exploratory effort in North America, U.S. total reserves of liquid hydrocarbons amounted to 4960 million tons at the end of 1959—an increase of 190 million tons—and Canadian crude reserves rose by 50 million tons to 525 million. A spectacular rise is noticeable in the total for Argentina, where the reserve figure of 280 million tons was exactly double that recorded a year previously. The other region in which estimated reserves had a considerable increase was in Africa, where Algeria (including Sahara) totalled 635 million tons compared to 455 million at the end of 1958. The figure for the section termed "Other Africa" showed a rise of 215 million tons to reach 300 million at the end of the year under review. This was the result of the important discoveries made in Libya and several parts of West and Equatorial Africa. Details are given in Table I.

TABLE I

WORLD "PUBLISHED PROVED" OIL RESERVES AS AT END 1959 AND 1958

(million tons)

Western Hemisphere	1959	1958	*Eastern Hemisphere*	1959	1958
U.S.A.			Middle East		
Crude oil ...	4,205	4,050	Iran	4,660	4,430
Natural gas liquids	755	720	Iraq	3,310	3,310
Canada	525	475	Kuwait	8,415	8,140
Mexico	345	345	Qatar	320	320
Argentina	280	140	Neutral Zone ...	935	850
Colombia	105	100	Saudi Arabia ...	6,660	6,275
Peru	45	45	Other Middle East	45	50
Trinidad	60	55	Total	24,345	23,375
Venezuela	2,580	2,325			
Others	55	55	Africa	935	540
			Western Europe ...	215	200
			East Indies	1,270	1,200
			Other Far East ...	85	80
			U.S.S.R. Bloc ...	4,065	3,750
Total W. Hemisphere	8,955	8,310	Total E. Hemisphere	30,915	29,145

World Totals: 1959—39,870; 1958—37,455.

Production

World production, at 1000 million tons, was 8 per cent above the total for 1958. In the U.S.A. production showed a substantial increase owing to the country's economic recovery and the effect of import controls, although output was only at about the 1956 level. Elsewhere in the Western Hemisphere the rise of Mexican production from 13 million to 14·6 million tons indicated the improving condition of that country's oil industry, whilst in Argentina the fruits of the acceleration in exploration of recent years resulted in a 34 per cent increase in output for that country.

The most impressive percentage increases were seen in Africa, where Algeria (including Sahara) rose by 225 per cent, Egypt (due to the accelerated production rate and the location of new Sinai deposits) by 50 per cent, and "Other Africa" by 56 per cent.

The jump of 54 per cent to a level of 6 million tons in the Kuwait-Saudi Arabian Neutral Zone's output was the most spectacular in the Middle East.

Consumption

World demand for petroleum products confirmed its trend of the previous five years at a rate of increase of about 7 per cent, implying a doubling in rate in 10 years. In Europe and N. America the rate of growth in fuel oil demand ran ahead of other products, whereas growth in demand for middle distillates was not as great as in recent years. The largest percentage increase for any world area over the year was that of the East Indies, which was 17 per cent and compared with its annual average rate of 3 per cent in 1954–59. Other areas with large increases were W. Europe, whose 11 per cent was a maintenance of the recent annual average, and Africa, whose rise of 10 per cent in 1959 contrasted with the annual average of 1 per cent over the past five years. Full details can be seen in Table II.

Supply and Demand

The proportion of world oil production entering into world trade, which had been increasing over the past few years, fell to just under 40 per cent. This was due to increased production from local sources, particularly in the U.S.A.

Refining

World refinery capacity increased by 5·5 per cent during the year up to the end of 1959 to reach 1064 million tons. This was somewhat lower than the growth of oil demand in the same period. All areas of the world shared in this increase, the largest proportional gains coming from Trinidad, W. Germany, and Japan, all of which had increases in capacity of over 25 per cent.

Tankers

The world tanker fleet showed an increase of over 5 million dw tons over 1958, to reach a total of 60·9 million dw tons (vessels of 2000 dw tons and over). Of this total recorded at the end of 1959, 22·3 million tons was owned by oil companies. Britain's share of the world total was 16 per cent, 3 per cent less than Liberia. Laid-up tonnage at the end of 1959 amounted to 6 million dw tons—some 2 million more than a year previously.

TABLE II

WORLD OIL CONSUMPTION 1959 AND 1958

	1959 *Million tons*	1958 *Million tons*	*Change* 1959 *over* 1958 (*per cent*)	*Change* *Average* 1954 *to* 1959 (*per cent*)	1959 *Share of total* (*per cent*)
U.S.A.	456	441	+4	+4	47
Canada	39	36	+8	+8	4
Mexico	14	13	+8	+7	1
Caribbean	25	25	—	+12	3
Other West Hemisphere	42	40	+5	+2	4
Total W. Hemisphere ...	576	555	+4	+4	59
Western Europe ...	170	153	+11	+11	17
Africa	22	20	+10	+1	2
Middle East	24	22	+9	+19	3
East Indies	7	6	+17	+3	1
Australasia	13	12	+8	+10	1
Other East Hemisphere	43	40	+8	+10	4
Total E. Hemisphere ...	279	253	+10	+11	28
World excl U.S.S.R., etc	855	808	+6	+6	87
U.S.S.R., etc	130	117	+11	+14	13
World	985	925	+6	+7	100

Historical

It can be seen from the tables of comparative oil statistics over the last 20 years that world oil production has risen from 274 million tons in 1938 to 484 million in 1949, and to 1001 million in 1959—an increase of 106 per cent over the 1938–59 period. In comparison, during the same period world proven oil reserves have risen by over 750 per cent—from 4585 million tons at the end of 1938 to 10,350 million at the end of 1949, and over 39,000 million 10 years later. World oil consumption during 1938–59 has grown from 270 million tons in 1938 to 482 million in 1949, and to 985 million in 1959.

★ ★ ★

Chemistry Research Grants

The Chemical Society announces that applications for grants from its fund for research assistance in all branches of chemistry will be considered in November next. Applications should be submitted on the appropriate form not later than 15 November 1960, and those from Fellows will receive prior consideration.

Forms of application, together with the appropriate regulations, may be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

The Application of Electronic Computers

Two and three-week non-residential courses on the business application of electronic computers will commence on 12 September and 7 November 1960 in London. Organized by Computer Consultants Ltd, Cecil Court, London Road, Enfield, Middlesex (from whom further particulars should be obtained), the courses are being held in collaboration with the leading computer equipment manufacturers.

IP COUNCIL

The following have been elected to fill casual vacancies on the Council: W. S. Ault and J. S. Parker for the period to the AGM in 1961 and G. Chandler until the AGM in 1962.

W. S. Ault, B.A., joined the Shell Group in 1936 at the Shell Haven refinery, and in 1939 was transferred to the Suez refinery of the Anglo-Egyptian Oilfields Ltd. In 1944 he became assistant refinery manager at Stanlow refinery, where he remained until 1946 when he was appointed technical adviser to Shell-Mex and B.P. Ltd. In 1949 he returned to the Shell Petroleum Co as manager of the Sales Technical Advisory Department, rejoining Shell-Mex and B.P. Ltd as manager of their Technical Department in 1952.

W. S. Ault

G. Chandler

Geoffrey Chandler was born in 1922 and educated at Sherborne and Trinity College, Cambridge. He completed his degree after the war, and then spent five years on the editorial staff of the *Financial Times* (which included a sabbatical year in the U.S.A. on a Commonwealth Fellowship) before joining Shell International Petroleum in 1956. He has been head of the Economics Division since 1957 and is a member of various IP Committees.

J. S. Parker, M.A., B.Sc., who served as the manager of Lobitos Oilfields Ltd's refinery at Ellesmere Port, Cheshire, from 1933 to end of 1958, when he retired from the post although remaining with the Company in a consultative capacity.

He first became a member of Council in 1945, and served as a vice-president in 1949–52 and 1958–1959. He was a founder and committee member of the Trinidad, Northern, and Stanlow Branches, and was twice the chairman at Stanlow. He was awarded the Eastlake Medal in 1958, and for many years has been particularly concerned with the Institute publications.

J. S. Parker

PIB Literature

Information memoranda sheets issued by the Petroleum Information Bureau which have been subject to the usual periodical revisions are those entitled "What Oil Means to Britain" and "Oil in the Middle East".

Both of these provide a good general introduction to its subject and the latter release includes maps of the area covering oilfields, refineries, and pipelines. They are obtainable, free of charge from the Bureau, at 29 New Bond Street, London, W.1.

Notes of the Month

First Stage Towards Export of Libyan Oil

Delivery of 40-ft lengths of oil pipeline pipe, the first ever used in Libya, has begun through use of a unique technique involving floating the pipe ashore at Marsa El Brega on the Gulf of Sirte.

In addition Esso Libya believes that the 30-in diameter, 4000-lb section of pipe is also the first of its size ever to be unloaded from a ship anchored in the open sea and towed to the beach.

A full cargo of pipeline sections arrived by sea from the U.K. with each section securely sealed with a large plastic plug, an Esso Libya idea which thereby makes the pipes watertight so they will float. When lowered into the sea, about a mile offshore, the pipes are towed by small boats to the beach, where they are loaded aboard a specially-devised car on a marine railway and pulled on to dry land. The unloading, especially in rough water, requires great skill and co-ordination between the ship's crew, the small boat handlers, and the men ashore. The present task of unloading the pipe and stacking it on the beach is being done by SAASCAM, a Libyan construction firm, under contract to Esso Libya.

This successful operation, which was accomplished with the co-operation of the Libyan Government, marks the beginning of a pipeline project which will reach south for approximately 100 miles to Esso Libya's new fields at Zelten in the Libyan desert. The crude oil it will carry north may become the first to be exported from Libya.

Esso Libya is also planning to build a loading terminal at Marsa El Brega so that crude oil can be delivered directly aboard tankships for transportation abroad.

The contract for the building of the pipeline from Zelten to Marsa El Brega has been awarded to the Bechtel Corp, and it is anticipated that the company will start work some time near the end of this year for completion in about six months from then. However, much more work will have to be done before the line can go into operation. This will include drilling additional development wells near the beginning of the pipeline and building terminal facilities at the other end.

Esso Libya's objective is to begin exporting Libyan crude oil sometime during the first half of 1962. The 30-in diameter all-welded and coated line will be laid underground for its entire length, and at one point of its overland route the pipe will lie about 100 ft below sea level. No pumping station will be built initially. The Zelten field is well above sea level and the combination of gravity flow, large diameter pipe, the location of storage tanks at Marsa El Brega, and the size of the planned underwater loading line will permit the full production of the field to be delivered aboard tankers without pumping.

The cost of the pipeline project under the present contract, which includes a stabilized road along the pipeline right of way, will be about $16 million.

Gulf Enters U.S. Pacific Market

Gulf Oil Corporation has acquired the assets of the Wilshire Oil Company, the independent oil refining and marketing company of Los Angeles, California. The Company's refinery is a 33,000 bd capacity plant at Santa Fe Springs, and distributes through California, Arizona, and Nevada.

Through this acquisition Gulf will be able to participate in the fast-growing west coast market for the first time.

Wakefields Become Castrol Ltd

C. C. Wakefield & Co. Ltd has changed its name to Castrol Ltd. The Company explains that, since the war, their business has grown enormously, and with the post-war generation, it is the name Castrol which has the greater significance. It is to simplify the work and the identity of the Group as a whole that they have, with reluctance, decided to lay aside their "family" name and to go forward under the title of their principal trademark.

New Estimate of Assam Reserves

DeGolyer and MacNaughton, independent geological consultants, have confirmed that recoverable crude oil reserves amounting to 29 million tons have so far been proved to exist in the Upper Assam areas to be developed by Oil India Private Ltd. The estimate is based on the latest appraisal of potential production data obtained from the Nahorkatiya and Moran oilfields.

The additional reserves indicated, but not confirmed by testing hitherto, have been appraised at approximately 13 million tons. In addition it is hoped that the further drilling planned will establish the presence of a further 20 million tons of recoverable reserves, and that together these reserves will enable the combined oilfields to produce at a maximum rate of three million tons per annum for an estimated minimum period of 15 years. The maintenance of this rate of production will, however, depend on the continued success of the drilling still to be carried out. It has been arranged that DeGolyer and MacNaughton will re-appraise the reserves at six-monthly intervals.

Attock Oil Company's 1959 Operations

The 1959 Annual Report of The Attock Oil Company Ltd announces that exceptionally heavy exploratory drilling was carried out during the year.

Production in 1959 amounted to 1,597,522 brl, compared with 1,564,909 brl in the preceding year. As has been the case since 1952, the bulk of this production was obtained from the Ranikot zone of the Dhulian field. However, it is reported that a deep test below the Ranikot to the base of the Eocene rocks is now drilling in previously untested horizons. The test well is a considerable distance to the west of any producing well, and good oil indications in the Ranikot section of the well indicate an extension to the productive limits of that zone. Crude oil output at each of the Balkassar, Joya Mair, and Khaur fields was maintained at previous levels.

Operations of Pakistan Oilfields Ltd, Attock's subsidiary, are reported as follows.

The third well at Karsal, which is being drilled by Pakistan Petroleum Ltd in a joint operation with POL, gave good flows of oil, but after the production of about 21,000 brl it was shut-in pending an investigation into the possibilities of acid treatment to improve flow. Preparations have begun for the drilling of a further joint well in the area.

The joint test at Domanda, in the N.W. Frontier, has been abandoned at 11,142 ft. Difficult drilling conditions have been encountered at the Mahesian well, 50 miles south of Rawalpindi, where a depth of 9424 ft had been attained with as yet no signs of oil.

A test well is projected in the Tanwin area, 8-10 miles from Chak Beli Khan where drilling was suspended because of the presence of large volumes of water under high pressure.

and the results of a seismic survey planned at Meyal will decide whether further drilling will take place there.

A new 32-in natural gas line, connected up to the Dhulian–Rawalpindi line 24 miles from Dhulian, was completed to the Wah cement works and Government ordnance factory.

The Edeleanu plant at the Rawalpindi refinery was being brought into commission at the time the report was published.

BP to Search for Oil in Greece

The British Petroleum Co. Ltd, in partnership with the National Bank of Greece, has signed an agreement for oil prospecting and exploitation rights over a land area of 5715 sq km (about 2000 sq miles) in the Province of Aetolia—Akarnania and the islands of Lefkas and Cephalonia in western Greece.

BP and the National Bank have jointly formed the Aetolian Oil Company SA to hold the concession, and operations will be conducted by BP Exploration Company (Greece) Ltd. Under the agreement the exploration rights last for 8 years, by the end of which time a development concession must be taken out. This concession would be for 30 years with a possible renewal for a further 10 years. It is planned that geological survey work will commence shortly.

Drilling Progress in Iran

The state of the various drilling operations outside the Consortium's agreement area of Iran was as follows at the 6 June.

National Iranian Oil Company

Alborz No 8: the well remains at 11,525 ft with the last casing at 10,697 ft, and testing is still in progress.

Sarajeh No 3: drilling at 12,013 ft with the last casing at 9396 ft.

Sarajeh No 4: the well is being tested, whilst the well depth is 11,825 ft and the last casing at 9231 ft.

Gorgan No 3 (north Iran): at a depth of 3120 ft, with the last casing at 1496 ft.

Gorgan No 4: drilling at 1400 ft and last casing placed at 736 ft.

Société Irano-Italienne des Pétroles (SIRIP)

At Sequta, in the Zagros agreement area, the well has reached a depth of 4825 ft.

At Sirip No 1, offshore in the Persian Gulf, drilling is in progress at 10,493 ft.

Iran Pan American Oil Co (IPAC)

The offshore wells have reached depths of 13,151 ft and 4006 ft respectively at A1 and B1.

BP Drilling in Libya

BP Exploration Company has recently started drilling two new deep test wells in Libya. These are well No B1-34, about 75 miles south of Tripoli, and well A1-80 in the Province of Cyrenaica about 325 miles south-south-east of Benghazi.

The drilling of well A1-35, about 80 miles east of Benghazi, has reached a depth of over 8000 ft.

In addition, seven seismic parties are working in various BP concessions and light mobile rigs are being used to drill water and shallow geological information holes.

The operational headquarters of BP Exploration Company (Libya) are in Benghazi. A telecommunications system provides a 24-hour cover to all field parties and drilling locations, including radio beacons on desert landing strips to aid charter aircraft which are flying over 250 hours each month on supply missions.

Australian Government Oil Search Report

A report giving a summary of oil search activities in Australia and Papua–New Guinea to June 1959 has been issued by the Bureau of Mineral Resources of the Department of National Development.

It is known as Report No 41A, and follows closely the pattern adopted in Report No 42 issued around the time of the strike of oil at Puri, Papua, in November 1958.

The information contained in the present report has been revised to the dates mentioned:—

Geological, geophysical, drilling and well status to 30 September 1959;

Petroleum tenements to 30 June 1959; and

Expenditure to 31 December 1958.

A new table included as an appendix shows the stratigraphic wells drilled under the Petroleum Search Subsidy Act 1957–58.

A perspective of the search for oil throughout Australia and New Guinea is given, with a discussion of present drilling indications and future prospects. In addition a list is given of the areas which, on available geological and geophysical information, are most likely to contain commercial accumulations of petroleum.

Australia Exploration Subsidy

The Australian Minister for National Development has approved five new applications submitted under the Petroleum Search Subsidy Act 1959. Three of these are in respect of geophysical surveys, while the remaining two cover stratigraphic drilling proposals.

The applications now approved, with the maximum permissible amounts of subsidy payable under the Act, are as follows:

Seismic Surveys	
West Australian Petroleum Pty Ltd, Dampier Fault, Western Australia ...	£63,395
Cree Oil Company of Canada Pty Ltd, Longreach, Queensland	£6,000
Frome-Broken Hill Company Pty Ltd, Port Campbell, Victoria	£35,215
Stratigraphic Drilling	
West Australian Petroleum Pty Ltd, Barlee, Western Australia	£40,000
Australasian Petroleum Company Pty Ltd, Iehi, Papua	£300,000

The total sum involved in these five applications is £444,610, of which £50,697 may be claimed for the financial year 1959–60, £293,913 in 1960–61, and £100,000 in 1961–62.

The Lack of Opportunity for Geologists

Within the next few weeks approximately 240 young Britons hope to graduate with an honours degree in geology, but prospects of employment in the U.K. are said to be precarious. British industry, therefore, should "awaken more fully to the realization of what geology can offer", and employ more U.K.-trained geologists, says Professor David Williams, president of the Institute of Mining and Metallurgy.

In a review of the man-power position, Professor Williams says that a 1959 White Paper showed there were then 843 geologists employed in the U.K., about half being engaged as university teachers, or on the Home Geological Survey. The remainder, many of whom were not graduates in geology, were mainly employed by the National Coal Board or manufac-

turing industries. Remarkably few were employed by mining organizations operating in Great Britain, by consulting economic geologists or civil engineers, by mineral brokers, or by the large users of minerals.

Between the two world wars the annual output of honours graduates in geology from all British universities probably averaged less than 30, whereas during the past 15 years it had been about five times as many, the total number during that period being nearly 2000. Many had abandoned geology as a career, about 300 had joined university staffs in the U.K. or the Geological Survey of Great Britain, and most of the others were now serving abroad, mainly with mining or oil companies, or on overseas geological surveys.

In addition to the 240 hoping to graduate with Honours, an equal number were now engaged on post-graduate research on the subject, of whom roughly 100 would probably gain an M.Sc. or Ph.D. degree this year.

"It seems clear, therefore, that unless this upward trend is reversed, possibly due to the precarious prospects of employment, there should be no dearth of recruits for the geological profession," Professor Williams goes on. "However, unless various industries awaken more fully to the realization of what geology can offer them, and take steps to enrol more geologists on their staffs, I fear that many young men may shrink from entering the profession. For my own part I am quite convinced that it would be to the benefit of several industries to employ more geologists than they have done in the past, and certainly not least the mining industry whose future prosperity is utterly dependent on the discovery of mineral deposits."

Professor Williams asks: "Are we in the British Commonwealth right in not making more practical use of geology, and the Russians wrong in having a Ministry of Geology and scores of thousands of geologists, including a vast host to sustain their ever-expanding mineral industry?"

Latin American Oil Refining in the Next Decade

E. W. Schnabel, Universal Oil Products' sales and licensing co-ordinator for the Latin American area, in a paper co-authored with S. W. Curry, manager of UOP's market research and economics department, prophesied at a joint meeting of the American Institute of Chemical Engineers and the Instituto Mexicano de Inginieros Quimicos, in Mexico City, that oil refining in Latin America would increase by more than 50 per cent within the next 10 years, and during that period about 17 new Latin American refineries would be built.

Pointing out that oil demand in Latin America had averaged an 8·6 per cent yearly increase in 1949–59—roughly twice the U.S. rate—Mr Schnabel predicted Latin American consumption would achieve 4·3 million bd by 1970 compared with the current level of some 1·7 million bd. Export of refined products by Latin America would be an additional 1·1 million bd.

The 73 existing refineries would add about 25 per cent to their size and approximately 17 more would be built, bringing the 1970 total to 90.

Consumption ratios of various products would continue to differ from that of the U.S., but the pattern would change markedly.

Rising proportions of oil would be consumed in the form of gasoline, kerosine, and distillate fuels, whereas residual fuel demand, in terms of total requirements, would decline. Lubricating oil consumption would remain at a rather constant percentage of total oil demand.

Crude Storage Tanks Ordered for Libya

Esso Petroleum Company Ltd, on behalf of Esso Standard (Libya) Inc, has awarded a contract to Chicago Bridge Ltd for the supply, delivery, and erection of four crude oil floating-roof storage tanks in Libya.

The tanks, which are being manufactured by Whessoe Ltd, measure 200 ft in diameter by 48 ft high, and will have a capacity of almost 10 million gallons each.

Unifining-Platforming Unit at Ruhrchemie AG

A combination UOP Unifining-Platforming unit has gone on stream at the Ruhrchemie AG refinery at Oberhausen-Holten, Western Germany. Full range Platformate from the 2000 bsd Platforming unit is blended with light cracked gasoline from a catalytic cracking unit to produce a 94–95 octane number (F-1 clear) premium gasoline.

Platformer feed stock, an Arabian naphtha boiling in the 185°–365° F range, is supplied by the 2900 bsd Unifining unit. In addition to pretreating 2000 bsd of naphtha for Platformer feed, the Unifining unit treats 900 bsd of light gasoline. Hydrogen for the Unifining unit is supplied by the Platformer.

Bearing Corrosion in Marine Steam Turbines

Work by research chemists of the Wakefield Castrol Group on the corrosion of white metal bearings in marine steam turbines has now revealed that the possible cause of the corrosion is stray electric currents.

This corrosion has been a problem for many years, and has taken the form of an attack on the tin matrix. Tin oxide, a very hard material, is a major component of the corrosion product. In some cases, this has formed to a depth of 10–15 thou and resulted in flaking with subsequent bearing failure. Similar, but much less severe, corrosion has been known to occur in land-based turbines.

Extensive research has sought the cause of this phenomenon. A major problem in this work has been to reproduce in the laboratory similar corrosion to that arising in service.

Electrolytic corrosion of tin in a normal tin/steel system could not occur since the steel would be the anode. But by applying a low electric potential (1·5 V) to a white metal/steel combination immersed in a very weak salt solution the arrangement has been reversed—the white metal being transformed into the anode.

In laboratory experiments, a corrosion layer 1·5 thou thick has been produced in a 40-hour period. This, by microscopic examination and X-ray diffraction analysis, was seen to be identical with that occurring in service. Alternating current has produced a similar effect but at a very much slower rate.

That the problem has become more common in recent years may well be explained by the increasing use of electrical and electronic equipment, including radar. The effects of these devices on the electrical conditions in propulsive machinery are not yet fully known.

Petroleum Chemicals at Grangemouth

British Hydrocarbon Chemicals Ltd has announced that the erection of its third ethylene plant at Grangemouth, Scotland, has been completed ahead of schedule and the plant is already on stream. It is believed to be the largest of its kind outside the U.S.A., and will more than double the existing capacity of BHC's two previous ethylene plants, which were first operated in 1951 and 1956 respectively.

Underwater Pipeline for Persian Gulf

Tenders for the supply of steel pipe for constructing a 20-mile submarine pipeline in the Persian Gulf have been sent out to British, Continental, and American suppliers by BP Trading Ltd.

The pipe is for Abu Dhabi Marine Areas Ltd (in which BP has a two-thirds interest and Compagnie Française des Pétroles one-third), in whose offshore concession the drilling barge *Adma Enterprise* has found oil some 60 miles from the Arabian coast.

The main pipeline, which will be just over 20 miles long and constructed of 18-in diameter pipe, will link a collecting platform located in the middle of the Umm Shaif underwater field with Das Island, where crude oil separators, storage tanks, and a tanker loading jetty will be erected. Each producing well will be linked with the collecting platform by a 6 or 8-in diameter submarine pipeline.

The value of the order for the pipe itself is expected to be about £500,000. During its manufacture special quality controls will be observed as part of the programme to ensure that the minimum attention will be required after it is laid on the sea bed. The pipeline will be encased in concrete to weigh it down and also to provide protection against corrosion. Because of this it will be very difficult to gain access to it after it has been laid in position.

Seventh Fawley Foundation Lecture

The seventh in the series of annual Fawley Foundation Lectures at Southampton University is to be given this year on 10 November by Sir Alexander Fleck, former chairman of ICI. The title of Sir Alexander's address will be "Science and Industry: A Blend with the Humanities".

The Foundation was established in 1953 between Southampton University and Esso Petroleum Company Ltd, to make provisions for the delivery and publication of a series of annual lectures under the general title of "Science and Industry". The first lecture was delivered in 1954 by Sir Harold Hartley, followed in succeeding years by Norbert Wiener, Sir Arnold Plant, Sir George Thomson, Sir Harry Pilkington, and Lord Adrian.

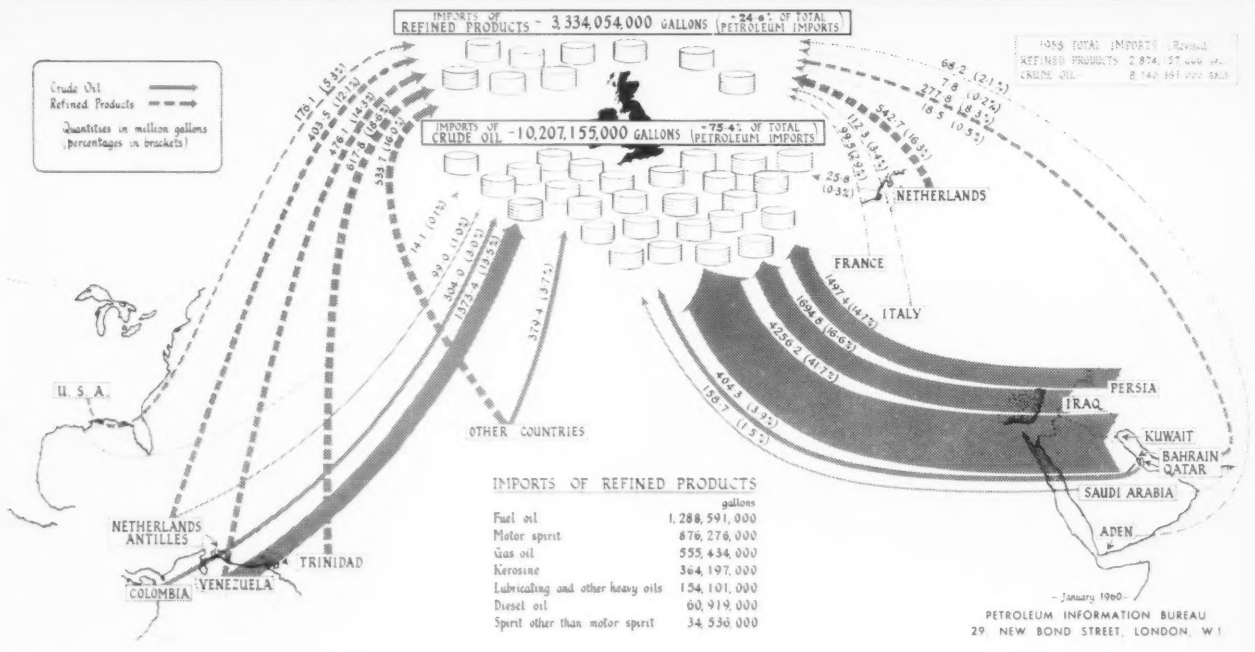
Chemicals Expansion at Fawley

Following the recent announcement of the £5½ million extension of manufacturing facilities for feedstocks for the chemicals industry at the Esso refinery, Fawley, a contract has now been awarded to Foster Wheeler Ltd for the detailed engineering and erection of the new plant.

The new units, which are Esso-designed, will include a steam cracker, and ethylene recovery and butadiene extraction plants. Construction will commence shortly and be completed by the end of 1961.

* * *

U.K. Imports of Crude Oil and Refined Liquid Petroleum Products—1959



Emission Microscope in Industry

The field emission microscope being used at Shell's Amsterdam laboratories. The image of the surface under study appears on the fluorescent bulb in the right foreground

An interesting phase of the fundamental studies of catalysis which are being investigated at the Amsterdam laboratories of the Royal Dutch/Shell Group is that in which a field emission microscope is used in the study of the activity of the metallic catalysts.

It is an essential feature of catalysis that molecules are absorbed on the surface of the catalyst. The emission microscope is being used to observe the mechanism of this absorption and to study the nature of the interaction between these absorbed molecules and the catalyst surface. The various crystal faces of the catalyst differ in catalytic activity owing to differences in geometrical structure, and the emission microscope permits a study of these differences.

The field emission microscope, or Müller projector, has been under development as a research tool for the past 10 years, but this is believed to be the first time industry has used it. It operates on the principle that most substances will emit electrons when a high voltage is applied to their surface. This is the principle on which the picture tube of a television works, and in fact the emission microscope is very similar to a television tube.

It is a glass tube one side of which has been coated with a fluorescent material to form a viewing screen. This screen fluoresces when hit by electrons which come in this case from the metallic catalyst crystal under observation. These electrons are accelerated towards the screen by an electric field of the order of 30 million V/cm, and as a result they form a greatly magnified image of the crystal surface. A linear magnification of one million times can readily be achieved.

Shell-U.S. Joint Venture to Market Plastic Film

A joint company is being formed by Shell International Chemical Company Ltd and National Distillers and Chemical Corporation, New York, to develop plans for the production and marketing of polyolefin film and plastic packaging materials outside the U.S.A. and Canada.

Companies of the Royal Dutch/Shell Group have substantial interests outside North America in the manufacture of polyolefins—basic plastic materials. National Distillers is one of the world's largest producers of polyethylene and owns the Kordite Company, a leading manufacturer in the United States of plastic film for packaging. It has recently also set up a company in Switzerland to cover sales and development of polyethylene.

The new joint company, which will operate from London, will be headed by Dr W. L. J. De Nie, currently a senior executive of Shell Development Company, New York. Dr De Nie's deputy will be Werner T. Meyer, who is currently in charge of Kordite's foreign operations.

Mobil Plans New Terminal at Barry

Mobil Oil Company will start work very shortly on the construction of a new sea-fed bulk terminal at Barry, Glamorgan. With a storage capacity of 5000 tons; 3500 tons for motor spirit and 1500 tons for gas/diesel oils, the new terminal will be established on a nine-acre site leased from the British Transport Commission at Barry Docks.

Coastal tankers from the Coryton refinery will deliver products to the new terminal for distribution by road tankers to consumer and retail customers in South Wales and parts of Herefordshire and Gloucestershire. It is expected that the new installation will be in operation by mid-1961.

CBMPE Chairman's Report

The Chairman's report for 1959–60 on the work of the Council of British Manufacturers of Petroleum Equipment gives details of the formation and subsequent activities of British Oil Equipment Credits Ltd, the CBMPE subsidiary formed in April 1959.

The description of the technical work during the year includes particulars of the Council's market information facilities, the standardization and technical committees, and the programmes of activities of the past year. Among the latter is the recent OEEC technical mission which came to the U.K. to study petroleum distribution and transport facilities, techniques, and equipment; and visited several refineries, research installations, and manufacturing plants in different parts of the country.

The technical reports which are included give particulars of technical and commercial services (including publications), technical study missions, and standardization appointments and publications. A separate published annex to the report surveys principal events in the oil and gas industries during 1959.

Development at Nahorkatiya

While drilling is continuing at Nahorkatiya, one of the two areas of Oil India Private Ltd in Upper Assam—63 wells have so far been drilled there—the construction of Zaloni, the Oil India township, is also progressing rapidly.

Extending over an area of about 825 acres, Zaloni is divided into two major sectors—industrial area and housing area.

One or two buildings in the industrial area are already in use, others are nearing completion, and the installation of a railway siding system is also under way.

The housing area, about 525 acres with 17 miles of roads, is designed to accommodate most of the employees in an environment in which all houses, including the labour quarters, are provided with electric light, gas-cooking chulas, running water, etc.

The speed of the construction work in Zaloni can be judged from the fact that acquisition of land for the township, most of which was a forest grant of the Zaloni Tea Estate, began in October 1958, and a plinth of the first house in the area went up in May 1959.

BP Gift for South Shields Technical College

A cheque for £20,000 towards the cost of building a new workshop training centre at South Shields (Durham) Marine and Technical College has been presented to South Shields corporation by BP Tanker Company. The cheque was handed over by J. Houston Jackson, managing director of the Company, to the mayor of South Shields at a ceremony attended by representatives of the county borough, the Ministries of Education and Transport, and various shipping interests.

The gift is the outcome of an agreement between the corporation and the Company to provide practical workshop training for apprentice sea-going engineers. Previously this training has been largely obtained in marine engine works and other shore engineering establishments, but it was considered that it could be carried out on a more systematic basis at a suitably-equipped technical college. Between 100 and 120 of the BP Tanker Company's engineer apprentices will each year undergo an intensive 21 weeks' tuition in the new workshop, which will also be open to apprentices from other shipping companies.

Much of the necessary marine equipment for the new workshop has already been presented by the BP Tanker Company. While the new workshop will not be completed before 1961, a pilot course is already being operated by the College on behalf of BP in existing buildings.

Filipino Oilmen Stay at U.K. Refineries

Nine technical staff from the Shell Company of the Philippines arrived in the United Kingdom recently on a two-year assignment for training and experience, in preparation for the setting up of a new refinery in the Philippines in 1961.

Four of the Filipinos, A. P. Yap, H. B. Aycardo, E. E. Cabrera, and A. D. Moredo will work at Shell Haven; the others, J. I. Cruz, R. R. Reyes, J. T. Lalic, J. J. Gochoco, R. L. Caguiat, will be at Stanlow. Another six technical staff will be spending eighteen months in Australia, at Geelong refinery.

Work is now starting on the new Philippine refinery, which will be south of Manila, at Tabangao, Batangas Bay, Luzon. It will cost £6½ million and its capacity will be 1,250,000 tons/year.

Members of the Shell Company of the Philippines on their arrival at London Airport

BP Overseas Staff at Perkins Engines

A party of BP lubrication engineers are seen in the test shop in Perkins Engines Ltd's service school at Peterborough during a six-week tour of British industrial organizations.

The engineers were from BP companies in South Africa, Australia, Switzerland, Norway, Germany, Belgium, Denmark, and Algeria.

Members of the party were:—P. C. Ruttledge, A.M.I.Mech. E. (*organizer of the visit*); P. R. Harvey (*BP Southern Africa, technical sales manager, Johannesburg Branch*); A. Marsh (*BP Australia Ltd, industrial lubricants manager, Retail Marketing Department*); M. Mosimann (*BPAG Switzerland, assistant to lubricants manager*); B. Novosad (*Norsk Braendselolje A/S Norway, lubrication engineer*); J. Stoldt (*BPAG Germany, chief assistant, Industrial Lubricants Section*); R. Block (*BP Belgium, technical engineer*); G. H. Burgess (*Power Petroleum Co. Ltd, U.K., technical representative*); W. Ogendahl (*BPOK Denmark, lubrication engineer*); and R. Revol (*Soc. BP Algeria, lubricants supervisor*).

Esso Aids to Advanced Education

The Vice-Chancellor of Southampton University recently announced the gift of £50,000 by Esso Petroleum Company to the University Centenary Appeal Fund. This follows a number of other donations to education made by the Company, including over £80,000 to St. Catherine's College, Oxford; £35,000 to Churchill College, Cambridge; and £13,000 to Manchester College of Science.

In addition to direct financial aid to universities and colleges, Esso finances up to 15 post-graduate studentships for research in chemical engineering or chemistry at five universities and colleges. The studentships are worth £400 per annum plus university and laboratory fees, and are tenable for up to three years. Graduates in chemistry or engineering, including Company employees, are eligible for the awards; the selection is made jointly by the university or college and the Company.

BP Kent Fire Service Collect the Trophies

BP's Kent refinery fire service had a particularly successful afternoon recently when they won no less than 10 trophies at the annual tournament of the British Fire Services Association (South-Eastern District).

BP Kent were among the 14 teams in the tournament which is open to industrial fire brigades throughout south-east London and the County of Kent. Of the seven team events on the programme which the refinery were able to enter, BP won five, while in a competition for individuals, members of the Kent refinery service took the first four places.

Technical Education in the Soviet Union[*]

By **PROFESSOR H. LEVY**

Lenin and others with him in the forefront of the 1917 Russian Revolution had written at that time a great deal on the relation between science and social change, and pinned their faith for the future on the planned development and application of scientific knowledge towards transforming what was then the most backward European country into a highly-developed scientific and technological society, with a material and cultural level of life that reflected that advance. It seemed that here was the beginning of an historic socio-scientific experiment.

The first point to realise is that the background of all this was very different from anything that had been experienced in Britain. The Industrial Revolution came to Britain slowly and gradually from the late 16th Century onwards, conditioning the people's thinking as it developed. There had been child labour in mine and factory, but never anything approaching the cruelty and oppression suffered by those who had to toil and slave under an autocratic Czardom. Suddenly, after a short generation the Sputnik flashes into the sky, for the first time in history photographs are taken of the back of the moon, the Russian H-Bomb becomes a reality, and with a shock we awaken to the fact that behind the new life that has emerged in Russia must lie a vast field of scientific and technological achievement and an educational system of high quality. A new society with a new people has been created.

To-day in the Soviet Union the census shows that in 1959 there was a total population of 208·8 million, with a surplus of 20 million women over men, precisely among those of 32 and over who bore the brunt of the second world war. In 1926 it was ascertained that approximately 50 per cent of the population was illiterate, to-day this has been reduced to 1·5 per cent; while out of every 1000 townspeople 32 are University graduates, and out of every 1000 country people 6 are graduates.

These figures give an indication of the dramatic changes that have taken place since the Revolution. There are other facts worth noting. In 1914 there were in the whole of Russia 16 technical colleges, all situated in St Petersburg and Moscow, with a total student population of 21,000 restricted to the upper class intelligentsia. To-day there are at least 195 such colleges, with 700,000 students, and they are distributed throughout every one of the Republics composing the Soviet Union, each one being administered in its local language. In this connexion it is necessary to realise that prior to the Revolution a number of these peoples had no *written* language. Alongside this, 310,000 are registered as research workers, and this number is increasing yearly by approximately 14 per cent. The annual output in this respect is three times that of the U.S.A. These data, drawn from official sources, indicate the transformation that has been effected in one short generation.

There is a point in relation to the incidence of work between the sexes that is worth mentioning. As has been pointed out there are 20 million more women than men, but naturally quite a proportion of these will normally be engaged in household duties. Regarding entry into the professions, however, there is full equality between the sexes. Some of the figures are significant. Among specialists in industrial organizations 31 per cent are women, in designing offices and in engineering 43 per cent, in agricultural experimentation 40 per cent, in education 39 per cent, and in pure science 52 per cent. There are more than 700 women university professors. It is clear that the social status of professors, teachers, engineers, and scientists ranks very high. In a country district the teacher has the status accorded in Britain to the local doctor; and according to the figures it would appear that school teachers are paid at roughly twice the rate received by their British opposite numbers.

During training at college, teachers devote one whole day per week working side by side with industrial workers in a factory, on a building site, or on an agricultural enterprise, taking part in discussions on wages and labour conditions. Their theoretical studies must be integrated with actual social practice. This Marxist principle—the unity of theory and practice—shows itself throughout the whole range of Soviet education. A child starting its schooling at 7 spends 8 years at the preliminary stage from which it emerges with a knowledge of the basic principles of science as they manifest themselves in actual practice within the surrounding community. The need for this is stated specifically as a demand on education. Thereafter, however, when the children pass on to high school, 55 per cent of their time is devoted to languages and history, and 45 per cent to mathematics, chemistry, woodwork, etc. At this stage the drive towards specialization is less acute than in Britain. Soviet journals are very much concerned with the fact that, recognizing the rapidity with which their society is changing under the impact of scientific practice, they see that by the time the boy or girl leaves school the world they will face will be vastly different from what it was when they entered, and that it is for this change that teachers must provide an appropriate education. Large-scale electrification, for example, is quickly transforming town and village, and with this, the thoughts, actions, and values of their inhabitants, so that the educational process must keep pace with this changing background. The same problem arises at a different level from the rapid mechanization of labour, and latterly out of automation—so utterly different from the excessive manual labour of the previous generation. All this, it is argued in these journals, calls for not a decreasing but an increasing degree of intelligence and understanding on the part of those who operate and control these machines, so that they may cope with any emergency.

The basic principle, then, is that indicated in the training of teachers, that all theorists must possess a sound practical basis on which to theorize, and all operatives must rest their practice on a sound theoretical basis. Over and above this both must have the opportunity to appreciate and even contribute to the arts as they express themselves in a society with this structure and these values; and all this to function not simply at the early student stage but also at the operative stage.

To understand how this is done we have to appreciate a fundamental distinction between a socialist and a capitalist society. Since industry in the U.S.S.R., like education, is

[*] Summary of paper presented to the IP London Branch on 22 March 1960.

socially planned, there is no basic obstacle to its functioning *within* the educational system. Unlike the arrangements made in other countries for vacation work for students, where individual firms at home and abroad have had to be coaxed to provide facilities, in the U.S.S.R. industry functions *within* the educational system, and vice versa. An industry may have its own educational establishment where the student working there has three free days each week for study. He knows, well in advance, where jobs are available—and industry where the qualified applicants are. Thus after his 8 years at school, he may enter one of these institutions, stay for three or four years, and by 18 or 19, if he is qualified, can pass on to the university stage. The educational system takes the fullest advantage of this socially-integrated industrial structure, and the university authorities say bluntly that they prefer students who, in addition to having reached the appropriate educational level, have had two years at least of industrial experience, during which time they have taken part in meetings and discussions about conditions of work, improvements, and wages. It is maintained that such undergraduates are, as a consequence, more mature and higher in educational understanding. The educational content can thereafter be made more concrete, while the student tends to plan his work more economically with due regard to the importance of time.

But the Soviet Union is a vast country with large agricultural areas, and to meet this wide dispersal of population a system of free correspondence courses has been introduced; but this is subject at the present moment to a great deal of criticism.

At this stage those qualified for the higher levels of education may proceed either to a general polytechnic institution containing many technologies—metallurgy, mechanics, building, electrical engineering, etc., or to a specialist institution such as the oil institutes of Moscow, Leningrad, Grodny, Sverdlovsk, etc., or finally to the university itself.

Educationalists there take the view that a high level of specialization is not inimical to a broad understanding, that provided a subject is seen in its proper context and perspective, historical and ecological, the deeper one penetrates into a field the broader can be one's understanding.

Those who proceed straight to the university (after usually devoting a couple of years to industrial experience) spend five years there, two to general study and three to highly-specialized study. Those who have prepared themselves for this by correspondence courses are given special encouragement if up to standard. At the end of this period, as is usual on the Continent, the student presents a thesis on a selected topic, and defends his conclusions in public. His examiners may be university professors or representatives from industry. In illustration I mention only the case of the University of Vladivostok, where, two years ago, 22 Doctorate diplomas were granted, all concerned with problems dealing with the Far Eastern Railway. It was estimated that when these projects are put into practical operation, the railway will save £300,000 per year. Of course not all theses at all universities are so closely linked with industrial practice. The U.S.S.R. could not have achieved the advances it has in the world of science had theory not also proceeded step-by-step with practice. The whole system however reflects the urgent desire on the part of the authorities for young people to feel that they are contributing in a very specific way to the development of their society.

Esso's Technical Sales Department

The new premises of Esso Petroleum Company's Technical Sales Department at Feltham, Middlesex, which were described in our last issue, were officially opened on 21 July by H. C. Tett, chairman and managing director of the Company.

Speaking prior to the unveiling of a bronze plaque, Mr Tett said that it gave him special pleasure to be there, as he started his career in the Company's laboratories 32 years ago and was, in fact, the Department's first manager at its previous location at Vauxhall, London.

Emphasizing the expansion of the oil industry in Britain, Mr Tett said that Britain was now using six times as much oil as it did when he joined the Company. "In the last ten years," he said; "our company has spent in Britain over £80 million on building and expanding our refineries at Fawley and Milford Haven. Much of this expenditure is devoted, not to producing increased volume, but to improving the quality of our various products. Obviously, it is of the greatest importance that the investment of such large capital sums must be for the right manufacturing equipment for the best processes which will produce the quantity and quality of products that our customers are going to require for a good many years ahead".

"The Esso Group world-wide", Mr Tett said, "employs nearly 4000 people in research and spends nearly £25 million on research and development. Here again it is of the greatest importance that the problems on which this very large research effort is spent must be chosen so that the requirements of the future as well as the present are met".

"These figures serve to emphasize why it is important we should have a good Technical Sales Department to serve as the link between the customer and our research departments and so to insure that our manufacturing activities are properly planned to provide for the future".

Dr W. E. J. Broom, manager of Technical Sales Department, in a speech of welcome to the guests, explained some of the functions of the Department. "We are part of the Marketing Department" he said. "Our primary job is to give technical assistance to the Marketing Department and to our customers. Perhaps one of our most important functions is to ensure that the quality of our products is up to our self-imposed standards".

Dr Broom pointed out that a lot of time and effort was spent in planning and designing future product quality and so, he went on to say, "This latter responsibility makes it necessary for us to have good contact with industry in order that we can sense the shape of things to come and make the necessary plans to ensure that our products will do the jobs required of them in the future. In fact there is not an aspect of the industrial activity of Britain in which we are not interested. We strive to make our products suitable for all these industries and we strive to understand the problems of these industries and what we must do to help them".

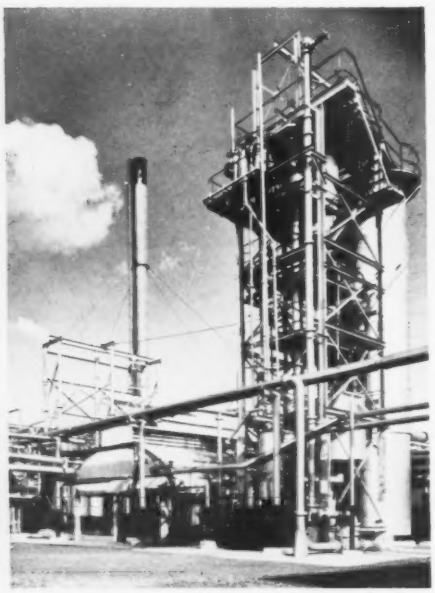
New Refinery Building at Ardrossan

The new administration building at Shell's Ardrossan refinery, Ayrshire, was opened on 27 June by Sir Fitzroy MacLean, Bt, C.B.E., M.P., and marked the completion of the major portion of a scheme of modernization and extension at the refinery.

Present at the ceremony were the Provost of Ardrossan, E. LeQ. Herbert and A. W. Hardie (managing directors respectively of Shell Refining Company Ltd and Scottish Oils and Shell-Mex Ltd), S. G. Wraight, O.B.E., manager of the refinery, and other guests.

It was pointed out by Mr Herbert at the lunch that the refinery supplied bitumens and road oils for road construction and repairs, and for a variety of industrial applications over the whole of Scotland (and to Northern Ireland also in the summer months). In addition large quantities of aviation fuels, motor spirit, kerosine, diesel and fuel oils, and lubricants passed through the installation for distribution throughout western Scotland and the Islands.

The refinery has a storage capacity of 150,000 tons of oil products. There are over 10 miles of pipeline within the refinery, and for cooling purposes the plant uses over 10,000 tons a month of fresh water drawn from the town's supply and some 90,000 tons of sea water.



Part of the bitumen plant at Ardrossan

BAPCO Report of Operations

The search for new oil resources in Bahrain was continued during 1959, and much effort was concentrated on repair and remedial work to obtain an increased production rate, according to the Bahrain Petroleum Company's 1959 *Annual Report to the Ruler of Bahrain and its Dependencies*. Production of crude oil in 1959 totalled 16,473,378 brl compared with 14,873,111 brl in 1958. Total cumulative output to the end of 1959 was 229,917,183 brl.

A mid-field exploratory well (No 188) was drilled to a depth of 3410 ft to test the producing potential of the Third Pay formations below the Bahrain Zones. The test results were still under examination at the end of the year. An exploratory well in the Buri area was abandoned at a final depth of 7675 ft as a dry hole.

Of the 188 wells so far drilled and completed in Bahrain 148 are producing oil and 5 producing natural gas.

The Awali refinery processed a total of 69,135,308 brl of crude oil and other stocks during the year. This was a drop of 1·8 per cent compared with the figure for 1958, and included 50,548,677 brl of Saudi Arabian crude. New TEL bulk storage and improved transfer facilities were partially completed to provide for safer handling of the product.

Work was begun during the year on a scheme to improve and extend the Company's oil-loading facilities at Sitra. A new island wharf, which will displace the present one, will provide two berths and equipment for ships of up to 45,000 dw tons. The present No 2 wharf will also be modified to take two 45,000 dw ton and two 18,000 dw ton vessels.

The value of the Company's local purchasing orders increased by 45 per cent in 1959 to a level of approximately Rs 13,152,054.

Natural gas from the Bahrain field is being increasingly used as turbine fuel for electricity generation at the Government power station.

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MIDDLE EAST OIL PRODUCTION

	June	*Jan-June*
	Tons	
Iraq Petroleum Co. Ltd ...	2,874,999	15,847,310
Basrah Petroleum Co. Ltd ...	964,636	6,054,366
Mosul Petroleum Co. Ltd ...	110,380	648,421
Qatar Petroleum Co. Ltd ...	658,701	4,006,844
Iraanse Aardolie Exploratie en Productie Mij	3,809,000	24,010,000
Kuwait Oil Co. Ltd	6,489,794	39,033,118
	Barrels	
Arabian American Oil Co. ...	37,211,810	221,864,138
Bahrain Petroleum Co. Ltd ...	1,350,669	8,201,470
Getty Oil Co. and American Independent Oil Co. (Kuwait-Saudi Arabia Neutral Zone) ..	3,943,131	23,459,443

The refinery throughput at Abadan of the Iraanse Aardolie Raffinage Mij for June was 1,358,000 tons, the total for 1 January to 30 June being 8,188,000 tons.

Crude processed at Aramco's Ras Tanura refinery during June was 7,389,957 brl, the total for 1 January to 30 June being 40,969,682 brl.

Books and Films

Handbook for Chemical Society Authors

The Chemical Society has just issued a volume of over 200 pages dealing with the information which an author writing for the Chemical Society may require to know. It covers the submission of manuscripts and their general layout, with details of the conventions, symbols, and nomenclature adopted by the Society, and Chapters I and II are a reproduction of the material in the Society's brochure "The Presentation of Papers to the Chemical Society".

Three chapters of the new book are devoted to the IUPAC rules of nomenclature of inorganic substances, of organic substances, and of steroids. The next two chapters are concerned with the nomenclature of carbohydrates and of organophosphorus compounds on which there is U.S.–British agreement. Physicochemical symbols, spectroscopical symbols, crystallography, and collated editorial reports on nomenclature are all dealt with in turn and the volume concludes with an extensive list of abbreviations of journal titles. A comprehensive index is provided.

In producing this work, the price of which is 6*s* to Fellows of the Chemical Society and 21*s* to non-members, the Chemical Society has performed a valuable task. The volume should be a standard work of reference for every author of a chemical paper whether for the Chemical Society or for any other chemical journal.

German Suppliers to the Mineral Oil Industry

The Fachgemeinschaft Apparatebau im VDMA of Düsseldorf has just issued the second edition of its buyers guide for the German petroleum industry. This volume of 167 quarto pages follows the lines of similar publications from other countries in that it comprises an index to the classified list of products manufactured by the members of the organization, a separate list of addresses of those members, and a section devoted to display advertisements of a wide variety of equipment and machinery. The publication is unique in one respect—in addition to text in English, French, German, and Spanish, corresponding versions in Arabic and Russian have been added. This in itself is an extremely useful feature. It is noted also that, in some of the entries in the display section, details are frequently given in English as well as in German. The address of the Association is: Luegallee 65, Düsseldorf-Oberkassel.

"New Polymers—New Problems"

The 1959 Edgar Marburg Lecture of the ASTM was entitled "New Polymers—New Problems", the lecturer being Herman Francis Mark, director of the Polymer Research Institute, Polytechnic Institute of Brooklyn. The lecture referred to polymers in the broadest sense of the word, pointing out their fundamental importance, as well as their immediate practical interest.

General properties were discussed in relation to representative metals and ceramics, and methods of enhancing those properties were dealt with. Specific properties referred to include molecular weight, molecular orientation, intermolecular reaction between chains, and the use of inorganic elements.

Copies of the lecture are obtainable from the ASTM, 1916 Race Street, Pittsburg 3, Pennsylvania, U.S.A. Price is $1.00 per copy.

Careers in the Chemical Industry

An overall picture of the wide field of career opportunities existing for young people in the chemical industry is well presented in a new booklet published by the Association of British Chemical Manufacturers and entitled *The Chemical Industry—A Career for You.*

It emphasizes the speedy growth and widening horizons of the chemical industry and describes its range of activities, the advantages of employment therein, and the careers which are available in chemicals through the varying means of entry.

A separate appendix provides a list of chemical firms offering career opportunities. The type of work done by the company and details of the sort of vacancies available, are given for each firm.

The Institute of Physics Report

The report of the Institute of Physics for 1959, which was adopted at the final meeting of the Institute before its amalgamation with The Physical Society, shows that at the end of the year the total membership in all grades was 6754, an increase of 445 on the previous year. The number of applications for membership continued to increase and reached a new record of 933 during the year.

The number of candidates entering for the Graduateship examination of the Institute continued to increase at a very satisfactory rate; 119 candidates took papers compared with 80 the previous year. Only 39 candidates were successful, and of these 13 held university degrees and 26 the Higher National Certificate in applied physics.

The Report again records expanding activities in many fields including education, scientific publications, conferences and symposia, and meetings arranged by the Branches and specialist subject Groups.

Fatty Acids and Fatty Alcohols

Published recently by Prices (Bromborough) Ltd as their Technical Publication No 6, "The Analysis of Fatty Acids and Fatty Alcohols" is a most comprehensive treatise on the subject. With a total of 149 pages, it is divided into five sections, the first two of which concern the fatty acids. After the initial chapter on the nature of these acids, the second chapter discusses the significance of and methods of test providing information on composition, on quality, and on behaviour in use.

The next two chapters deal likewise with the fatty alcohols and the final chapter, on the examination of commercial products, first gives data on sampling tools and procedures. The book then concludes with details of apparatus and procedures for 43 methods of test.

The book is based on the long experience of the Company in this field and has been brought up-to-date by the inclusion of chapters on gas chromatographic and uv spectrophotometric methods.

To those engaged in the field of oleo-chemicals this book should be of considerable assistance and those interested are advised to write to the Commercial Sales Manager, Prices (Bromborough) Ltd, Bromborough Pool, New Ferry, nr Birkenhead, for a complimentary copy.

Dechema Volume on Distillation Engineering

Fortschritte der Destilliertechnik (Progress in Distillation Engineering) is the title of Volume 37 of the Dechema Monographs which contains an account of three comprehensive experimental investigations on rectifying columns.

The first study reports on the properties of two-phase flow in rectification in packed columns. This investigation originated in the Forschungsgruppe Wärmeund Kältetechnik at the Max-Planck Institut in Gottingen, where systematic work is being carried out on various problems connected with rectification engineering.

The second study, on control problems in continuous distillation columns, was carried out in the Institut für Mechanik of the Technische Hochschule Hannover.

The third study in this volume was carried out in the Institut für Thermodynamik und Verfahrenstechnik of the Technische Hochschule Hannover, and has led to progress particularly in the application of the similarity theory to the processes in rectification columns.

This volume of the Dechema Monographs is published by Verlag Chemie GmbH, Weinheim Bergstrasse, Frankfurt-am-Main. The price is DM 17 to Dechema members and DM 21·25 to others.

"Chemical Plant Instrumentation"

Under this title, the Association of British Chemical Manufacturers has issued a useful collection of articles on the main subject of the use of measuring instruments. The nine articles cover temperature measurement by thermocouple, absolute pressure, steam flow, analytical instruments, gas chromatography, gas analysis by infra-red analysers, pH, flue gas analysis, and smoke density. The articles were originally issued in typescript form as a series of notes, but demand has warranted a more permanent publication. Price of this 55-page book is 7*s* 6*d* post free to non-members of ABCM (6*s* to members), and cash with order. Address of the ABCM is Cecil Chambers, 86 Strand, London, W.C.2.

Bomb-Calorimetric Measurement of Heat of Combustion

A new publication from the National Bureau of Standards gives detailed descriptions of apparatus and methods used by them for precise determinations of heats of combustion of liquid hydrocarbon fuels.

Standard methods of moderate precision for bomb-calorimetric measurement of heats of combustion of solid and liquid fuels are published by the ASTM, but in many fuel applications the heat of combustion is required with an accuracy of approximately 0·1 per cent, which is probably not attainable with the ASTM methods, but which can be obtained with less time and effort than is required in the most precise measurements.

The NBS Monograph describes the apparatus and methods used at the Bureau for such an intermediate determination. Numerical examples are given of methods for calculating the results of measurements from observed data, and it includes techniques of making and filling glass bulbs for containing samples of the volatile liquid fuels.

Precise Measurements of Heat of Combustion with a Bomb Calorimeter, by R. S. Jessup (NBS Monograph 7), price 25 cents, is obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Foreign remittances must be in U.S. exchange, and should include an additional one-fourth of the publication price to cover mailing costs.

Oil Tanker Trade Outlook 1960-63

Westinform Shipping Report No. 156, Oil Trade Outlook 1960–63, sets out to show the kind of changes which are likely to take place in the tanker world over the next three years or more, chiefly in order to give some idea of alterations in the composition of the tanker fleet, the extent to which it may be engaged in carrying out long-term charters, and its adaptability to a changing trade pattern.

The growth of the tanker surplus is traced from 1957 up to the present, covering the post-Suez period. Scheduled deliveries of new tankers are shown in tabular form up to the end of 1963, and estimates are given of the effects that building programmes will have on the supply of vessels. Future growth in the total of supply of tankers is then related to changes in trade patterns, with particular reference to developments in the Sahara. A more extended section deals with growth of demand in the main consuming areas, especially Western Europe, the United States, and Japan, and separate estimates are given of the additional tanker tonnage which will be required to meet these demands. On two separate sets of assumptions, fleet growth is shown to be too fast to allow of any significant reduction in the tonnage surplus.

The final section deals with re-deliveries of tankers from long-term charters and the possible reactions of major charterers, and of independent owners, to a very prolonged market depression.

Copies of this report can be obtained from W. G. Weston Ltd, 47–48 Piccadilly, London, W.1, at a cost of £2 each, plus postage.

New Mobil Road Maps

Now available for motorists in the British Isles are the first two road maps in a new series being produced by Mobil Oil Company. Covering the four areas of south-east England, south-west England, Wales and the east and west Midlands, they are available from all service stations which retail the Company's products. Eventually, three other maps will be produced: for northern England and southern Scotland; northern Scotland and Ireland; and the London area and central London itself. The new maps are produced in full colour on both sides of a single sheet and some of the information included is quite new to maps of this sort, and should appeal to all types of road users.

Information contained on the maps includes insets of town plans, all numbered roads (including the M1 and other by-pass schemes recently completed), and mileages between the principal towns. Places of interest, such as cathedrals, abbeys, castles, and historic houses are also shown, as are battle sites, ruins and National Trust Properties, and areas of outstanding natural beauty. In addition, race courses, golf courses, car racing circuits, view points, woods, and picturesque stretches of road are also marked. Finally, for the holiday traveller, sandy beaches are indicated by yellow marking. A feature of the series is that each map is arranged so that it can be read like a book, making it easy to handle in the car, and rendering it such that even motorists' wives should be able to navigate in complete confidence.

The maps, priced at 1*s* each, have been produced for Mobil by A. W. Gatrell & Co. Ltd of London. They are on a scale of 5 miles to 1 in for England and Wales, 8 miles to 1 in for Scotland, 10 miles to 1 in for Ireland, 1 mile to 1 in for the London area, and 1 mile to 5 in for Central London.

BP Films Catalogue

A new illustrated catalogue of British Petroleum films has just been published, which includes a brief synopsis and other details including the running time of each film.

The subject of the films, which are available on free loan for private showing, ranges from underwater exploration to the history of aviation, from life aboard a tanker to motor racing and the crossing of Antarctica. Copies of the catalogue are available free from BP Information Department, Britannic House, Finsbury Circus, London, E.C.2.

British Standard

Bitumen road emulsion (anionic)

BS 434:1960 is the third revision of the British Standard first published in 1931 under the title *Bitumen road emulsion for penetration (grouting and semi-grouting) and surface dressing*. The title has been changed in order to indicate not only that the scope has been widened, but also that the standard does not deal with the cationic emulsions which have been developed comparatively recently. It is aligned with BS 2542, *Recommendations for the use of bitumen emulsion for roads*, in that it also covers tack-coating, retreading, concrete and soil-cement curing, slip coats, pre-mixing, and mist-spraying.

Also new in this revision is the "Test for stability to mixing with coarse aggregate (aggregate mixing test)" which is designed to give a quantitative appraisal of the stability of emulsions to mixing with aggregates. Provision is now made for testing and certification under the BSI Certification Mark Scheme.

Copies may be obtained from the BSI, Sales Branch, 2 Park Street, London, W.1, price 7*s* 6*d* (postage extra to non-subscribers).

CBMPE Arabic Edition

An Arabic edition of its quarterly magazine *British Petroleum Equipment News* has been published by the Council of British Manufacturers of Petroleum Equipment. Its introduction is a recognition of the need for the English-language petroleum press to bring its news and views to increasing numbers of non-English-speaking executives within the industry throughout the world.

The edition is one of the occasional special language issues published at intervals, the editorial content being a selection from recent numbers of the English-language version. Subjects of interest to be featured in the edition include the offshore drilling off Das Island, the BP tanker terminal at Finnart, the importation of liquefied natural gas to the U.K., and the developments at the Esso refinery under construction at Milford Haven.

"Overseas Newspapers and Periodicals"

This 460-page book published by the Publishing and Distributing Co. Ltd (177 Regent Street, London, W.1.) at 30*s*, gives details of newspapers and periodicals published in various countries, the detail being concerned with advertising requirements and rates. The entries range from advertising to wood and woodwork, but the number of entries under the heading of "Petroleum" is remarkably few.

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DOW CREATES AN INTERNATIONAL ORGANIZATION

The sixty-second annual report of the Dow Chemical Company, for the 1959 fiscal year, records a year of heartening recovery from the depressed economic conditions of the previous year which had resulted in a marked decline in sales and earnings. Net sales in 1959 rose by over $69 million to a total of $705,442,403, whilst the figure of net earnings at nearly $63 million, was a rise of some $17 million over the previous fiscal year. Total sales revenues were produced by the Dow Group's major categories of products in the following percentages: chemicals 51, plastics 35, magnesium 8, agricultural chemicals 6.

Probably the most noteworthy aspect of Dow's activities in 1959 was its greatly-increased scope of business outside North America.

Export sales through Dow Chemical International Ltd SA reached a new record with an increase of 13 per cent over 1958, and accounted for about 10 per cent of the Company's total consolidated sales.

The expansion of the overseas business and the opening up of opportunities for attractive investments abroad necessitated a major re-organization of Dow's activities in that sphere in order to proceed rapidly with construction of foreign manufacturing operations. As a result, an organization which for many years has been considered essentially a domestic U.S. company has undergone a rapid metamorphosis over the last year or so—a shift of emphasis from export selling to truly international operations involving overseas manufacturing and marketing.

To finance overseas manufacture, Dow Chemie AG was formed in Basle, Switzerland, as a holding company. Dow Chimica Italiana SpA was formed in Italy for manufacture and sales activities, and the investment application for a polystyrene plant in Greece was approved by the Government of that country. In France, a plant for the manufacture of *Styron* and *Saran* is to be built in conjunction with Cie Pechiney, whilst the Company's Dutch subsidiary, Nederlandsche Dow Mij NV, is being expanded by the construction of a styrene-butadiene plant and a phenol plant at Rotterdam.

A company, Deutsche Dow Chemie GmbH, has also been formed in Germany to provide oil and gas field operators with acidizing, fracturing, and cementing services. Elsewhere, Dow has joined up with CSR Chemicals Pty Ltd in Australia for the manufacture of styrene and other products at Melbourne; completed a styrene monomer plant at Kawasaki, Japan; established Dowell Division of Dow Quimica Argentina SA for the servicing of oil and gas wells in that country; and in addition opened sales offices in many cities throughout the world.

Oil Companies Invited to Join Oil Search in India

On 25 November the Petroleum and Natural Gas Rules, 1959 came into operation in India, superseding the P.C. Rules, 1949, which had governed exploratory operations for oil for nearly a decade. One important departure was the provision for grant of licences and leases on the basis of negotiations leading to specific agreements. The reason behind the new legislation was summed up by the Minister of Mines and Oil in a statement made in the Parliament on the eve of the new legislation, thus:—

> "A large-scale oil exploration programme must be undertaken involving expenditure of great amounts of foreign money in a comparatively short time if we have to attain the target of producing about 14 million tons of crude oil by 1966. The government has, therefore, decided to invite foreign oil explorers also to join in the quest for oil in India, subject to mutually-acceptable terms for exploration and also assuring that such arrangements with foreign oil explorers fall generally within the ambit of India's industrial policy resolution. With a view to creating these conditions the government has finalized its new Petroleum and Natural Gas Rules and they are being published immediately."

The new Rules provide for the entry of private enterprise in the field of exploration in India on the basis of negotiation. This, however, does not indicate any radical deviation from the existing policy, for the Industrial Policy Resolution, 1956, which included Mineral Oil in Schedule A thereof (among industries the future development of which would be the exclusive responsibility of the State), does not preclude the expansion of existing privately-owned units or the possibility of the State securing the co-operation of private enterprise in the establishment of new units when national interests so require, subject to the State taking steps to ensure that it had the requisite powers to guide the policy and control the operations of the undertakings.

Pursuant to the promulgation of the new Rules, an informatory booklet entitled *Oil Prospects in India* was circulated in foreign countries. The information contained therein included the Oilfields (Regulation and Development) Act, 1948, the Petroleum and Natural Gas Rules, 1959, as well as broad details of oil prospects in various sedimentary basins, and information on direct taxation in India. Through this booklet, the Government invited the expression of interest from parties desirous of joining the quest for oil in India by 31 January 1960. This date was subsequently extended to 31 March 1960, so as to enable some of the oil companies not acquainted with conditions in India to express their interest.

In response to the invitation, a number of established oil companies from different countries communicated their interest. This was followed by discussions and exchange of information between the Government of India and some of the companies. The discussions revealed a general desire to know more about the geological data of different regions. To assist in providing such information and in the selection of specific areas, a further communication was sent on 18 May 1960 to all those companies who had expressed interest. This letter provided a classified description of oil-bearing areas in two categories, one consisting of areas open for grant of licences and leases for direct operation by private parties, and another of areas where operations could be conducted only in participation with the Government's exploration agency. It also included a list of documents, published and unpublished, containing information on the surface and sub-surface geology of the various regions, and also the text of the Industrial Policy Resolution within the ambit of which negotiations were to be conducted. The letter called upon parties to make a detailed and specific proposal in respect of one or more of the blocks described, by 30 May 1960. Such proposals were to relate, *inter alia*, to

(1) the extent to which parties would be prepared to enter into participation in capital and operations with the Government of India;
(2) provision for meeting abortive expenditure in full or in part;
(3) in the event of petroleum/natural gas being found in commercially-exploitable quantities, the extent of profit sharing and sharing of expenditure the companies would be prepared to accept, and/or the extent of the oil-bearing areas they would be prepared to surrender; or the extent of fixed return they would desire to have on the capital employed;
(4) agreement to settle at the time of petroleum/natural gas being found, on a negotiated basis, the production programme they would agree to on discovery of petroleum, linking it with the quantum of capital proposed to be employed;
(5) the minimum area for which companies would like to obtain licence/lease and the minimum period thereof, and the extent to which they would agree to reduce the area during the successive stages of the term of the licence or lease;
(6) particulars and details of the programme of work the companies would propose to undertake in respect of geological and geophysical surveys, installation of drilling equipment, and exploratory drilling;
(7) estimate of minimum expenditure and time schedule of the expenditure;
(8) arrangements and terms regarding transportation and disposal of crude oil and/or natural gas which may be produced;
(9) agreement to the registration of the company to be formed for conducting operations in accordance with the companies Act 1956;
(10) agreement to undertake employment and training of Indian personnel to the fullest extent possible for the purpose of operations to be agreed to;
(11) the extent to which companies would be prepared to train Indians in India and abroad for the purpose of projects other than those which may be agreed to with them; and
(12) agreement to pass on all information, technical and financial, concerning their operations to the Government.

The parties were also to state the manner in which they proposed to fulfil the requirements of the Industrial Policy Resolution, and whether they were prepared to be considered for arrangements covering only exploration and production, and excluding refining and distribution.

In response to the latest communication, some of the parties have already sent their experts to study the data available. It was expected that actual negotiations would start in July 1960.

PETROLEUM TECHNOLOGY COURSE

A course of twenty-two lectures on the General Technology of Petroleum will be given at Sir John Cass College, Jewry Street, London, E.C.3, on Thursday afternoons beginning on 29 September 1960.

The course has been arranged for those who are engaged in non-technical departments of the industry and also for technical personnel who, being employed in one section, wish to obtain a simple working knowledge of other branches of the industry. Visits to refineries and research stations are being arranged. The fee for the course of lectures is £3.

Warren Spring Laboratory

The *Report of the Warren Spring Laboratory* of the DSIR for 1959 also includes the report of the Laboratory Steering Committee for the period 1 July 1958 to 31 December 1959. The decisions of the committee on the scope and type of work to be done at the Laboratory in relation to similar activities at other national research establishments are reviewed, together with particulars of the implementation of such decisions.

In the report of the director are included the organization and description of the Laboratory, the various divisions of research being undertaken, and work on human sciences, general services, and information and publicity. Among the research items undertaken during the year the following are of particular interest to the petroleum industry.

Atmospheric Pollution

Work has been carried out on the problem of acid smuts from the combustion of fuel oil by seeking to minimize the production of the finely-divided carbonaceous precursors of these smuts. An experimental study of the effects of burner design and conditions of operation on the formation of carbonaceous material during fuel oil combustion was made, using a water-cooled combustion chamber constructed to simulate a shell-type boiler.

Five burners differing in their principles of atomization were tested, all of which produced some solid material, the amount varying with the type of burner and the proportion of excess air. The production of solids was at a minimum for about 35 per cent excess air—corresponding to 11·5 per cent of carbon dioxide in the flue gas. The solids increased rapidly as the excess air was reduced below this value.

Experimental work on the removal of oxides of sulphur from flue gas has been continued, and in particular methods have been considered that do not cool the gases and thus decrease the buoyancy of the plume and hinder its dispersion.

It is also reported that methods of removing smoke from motor vehicle exhaust gas are being studied. Tests with a supported platinum catalyst, known to be effective in bringing about the combustion of unburnt constituents of such gas, showed that it was ineffective at the temperatures that could be maintained by diesel exhaust gas, although catalytic combustion occurred at considerably higher temperatures. Preliminary tests with filters are said to have given more promising results, and a pad of slag wool removed 85–90 per cent of the solids in diesel-engine exhaust gas.

Preliminary tests with stationary vehicles on the improved dispersal of exhaust gases as they leave the vehicle and before they can be inhaled, indicated that a carbon monoxide concentration of several hundredths of one per cent persisted for an appreciable distance from the vehicle. Its effect on pedestrians depended largely on the geometry of the tail pipe: where the exhaust gas was projected toward the centre of the road there was no measurable amount of carbon monoxide above the pavement.

The Fischer-Tropsch Process

The current programme of work on the Fischer-Tropsch process on both laboratory and full scale, to obtain information for the development of a process of potential industrial value, has continued. Attention is being concentrated on the synthesis of oil, using a liquid-phase system in which the process gas is passed through a suspension of catalyst in oil.

The main objectives are the development of iron catalysts possessing high activity and selectivity, and the design of a suitable type of reaction vessel and method of operation. Research is also being carried out on the more fundamental aspects of catalysts and reaction mechanism in order to identify and eventually control the factors which affect catalyst activity and life and the composition of the products.

At present the catalysts which appear to be the most suitable for the Fischer-Tropsch synthesis in a liquid-phase (slurry) system consist of precipitated iron oxides containing potassium (as potassium carbonate) as the promoter during their preparation. Current studies are directed to developing improved catalysts of this type.

It is reported that the effects on performance of variations in composition and method of manufacture of catalysts based on iron oxide are being investigated, largely on empirical lines, in collaboration with a British firm experienced in the manufacture of catalysts. Among other things it was found that variation in the ratio of ferric to ferrous iron in the initial stages of preparation had little effect on the final composition of the catalysts, in which practically all the iron is present in the ferric form, but the catalyst activity decreases and the selectivity increases with a rise in the initial ratio of ferric to ferrous iron.

In work on the activation of catalysts, analyses of the effluent gas have shown that evolution of carbon dioxide starts at a relatively low temperature; as the temperature is increased the proportion of carbon dioxide rises fairly rapidly and then falls, reaching a minimum value at a temperature of 285°C. A catalyst of high activity is obtained if the activation treatment is ended at this stage.

In the sphere of catalyst research an investigation is being made of the physical properties (especially electrical properties) and chemical reactivity of iron oxide catalysts. Progress has been made in the preparation of homogeneous mixtures of ferric oxide with *di-* and *tetra*-valent oxides in known crystalline form. These will be used to determine the effect of defective structure on chemical reactivity.

The study of the beneficial effect of gamma radiation on the activity of mill-scale catalysts for synthesis has been continued.

As relatively little has been published on the fundamental catalytic properties of metallic iron a study has been made of the absorption of hydrogen on scrupulously clean, evaporated iron films, with the object of obtaining thermodynamic data related to the absorption process.

The *Report of the Warren Spring Laboratory* 1959 is published by HMSO, price 3*s* net.

RESEARCH AT THE HERIOT-WATT COLLEGE

The second volume of the Heriot-Watt College's *Bulletin of Publications* has now been issued, and together with Volume No 1 completes a survey of the past 10 years research work in the College.

It contains details of the subjects of successful theses submitted for higher qualifications; research publications; and review articles.

THE NEW "BLUEBIRD" ATTEMPT ON THE LAND SPEED RECORD

A new *Bluebird* is about to join the illustrious line of previous cars and boats to carry that name—the CN7, to give it its design mark, with which Donald Campbell will make his first attempt on the world's land speed record at the Bonneville Salt Flats, Utah, in September this year. The present record has remained unbroken since 1947, when the late John Cobb took it to 394·196 mph.

Donald Campbell already holds the water speed record, and has in fact broken it on no less than six occasions in the past five years with the same boat. It was following his second successful attempt in November 1955 on Lake Mead, Nevada, that Campbell conceived his ambition to try for the land speed record as well, and this year there will be no less than four other contenders at Bonneville for the title, "fastest man on earth". All four are United States undertakings.

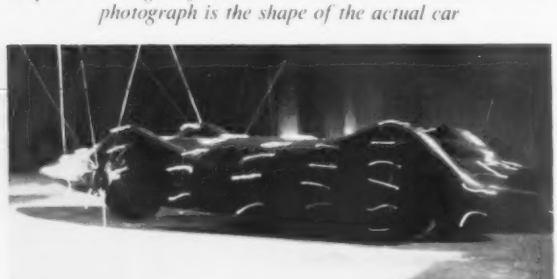
Five painstaking years have gone into the design and building of the new *Bluebird*, and the final result, when the car is finished later this summer, will be an all-British achievement. Sixty-nine leading British companies, manufacturing everything from ball-bearings to the turbine engine itself, have overcome problems never before met in the field of engineering.

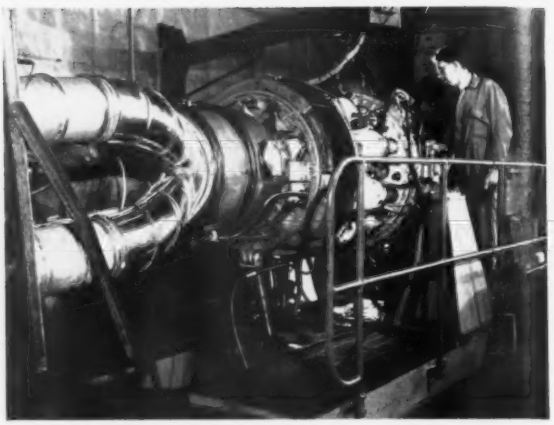
Work on the design began in January 1956, and was entrusted to Kenneth and Lewis Norris at Norris Brothers, consulting engineers, the designers of the *Bluebird* boat. The basic requirement was for an ultimate peak speed of 500 mph. The immediate objective is a new world's land speed record of 400 + mph, and Campbell had already decided that the engine he required was a Bristol-Siddeley *Proteus* free turbine. Four-wheel drive was considered essential, for which the engine required modification.

The regulations of the International Automobile Federation ruled out the use of a pure jet, or rocket engine. And manufacturing transmission and reduction gear units to take the power from the engine to the wheels was one of the most difficult problems that had to be solved.

The finished car will weigh 8000 lb, giving it an unprecedented power-to-weight ratio of approximately 2 lb for 1 bhp. The engine develops more than 4000 bhp. The overall body dimensions are: length 30 ft; width 8 ft; height 4 ft 9 in; wheel base 13 ft 6 in; track 5 ft 6 in. Suspension is fully independent, with wishbone and oleopneumatic spring and damper units allowing plus or minus 2-in vertical wheel movement. The steering is of conventional pattern to give a wheel deflection of 5° either side of the centre line.

During designing of the new Bluebird various models were given wind tunnel tests by the Aeronautics Dept of the Imperial College of Science. The model shown in the photograph is the shape of the actual car





The Bristol-Siddeley "Proteus" gas turbine undergoing test runs at the Company's Patchway works near Bristol

The frame construction involves the use of light alloy foil formed into a "honeycomb" sandwich, $\frac{3}{4}$-in thick, and faced on either side with alloy sheeting. Four longitudinal members of this material form the basic frame, joined together by four cross members forming separate compartments for the cockpit, engine, transmission gear units, and wheels. Air from the air intake at the front of the car is ducted on either side of the cockpit to the engine. Two fuel tanks, with a total capacity of 25 gallons, are mounted on either side of the car, just forward of the rear wheels.

There is no clutch or conventional gearbox in the *Bluebird*. Power is transmitted by the gas stream between the primary and power turbines—there being no direct mechanical link between the two. In operation, air is induced at the air intake and passes to a multi-stage compressor. Here it is compressed and fed into a series of combustion chambers. Fuel is injected into the air stream in each chamber, and burns, imparting additional energy to the incoming air. Some of this energy drives the first turbine, which in turn drives the compressor. The excess power, governed by throttle opening, is automatically absorbed by the second, or power, turbine, which is directly connected through the reduction gears to the drive shafts connected to the four wheels of the car.

In operation the engine will be started and run up to a pre-determined compressor speed with the car locked on the brakes. When this point is reached the brakes will be released and the car will accelerate at a rapid but progressive and controlled rate to the maximum speed. Full torque cannot be applied until the car has reached 200 mph; if applied at a lower speed it would result in drastic wheel spin.

Stopping the car in the distance available was an additional problem. The maximum length of the Bonneville Salt Flats straightway is 15 miles, and since the measured mile is in the centre there is a distance of seven miles in which the car has to stop after reaching anything up to 500 mph.

It was decided that air brakes would be used to slow the car to 400 mph, and then disk brakes would be applied. These disk brakes will have to bring the car from 400 mph to

a halt in 60 seconds. The total amount of energy to be dissipated during the 60 seconds of braking is 75 million ft lb.

This is the first time such a project has been based on a turbine engine, and the knowledge and experience gained with new materials, structures, brakes, tyres, bearings, and suspension systems and lubricants will all help to make for better, safer, motoring in the future.

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Lectures, Courses, and Conferences

Course on Lubrication

A course of nine evening lectures on lubrication is being held at the Department of Civil and Mechanical Engineering of the Huddersfield College of Technology, on Thursday evenings commencing 6 October 1960.

The lectures in order of presentation are as follows:

"The Evolution of Lubricants", by N. Haigh (D. Battye & Son Ltd);
A film on "Basic Principles of Lubrication", presented by G. H. Clark (Esso Petroleum Co. Ltd);
"Lubricant Prescription and Specification", by E. G. Ellis, B.Sc.;
"General Properties and Characteristics of Lubricating Greases", by H. Wells (T. H. Newsome & Co. Ltd);
"Solid Lubricants", by H. Peter Jost, M.I.Mech.E., Mem.A.S.M.E., M.I.Prod.E., and K. S. Paul (Molybdenum Disulphide Ltd);
"Quality Control Aspects of Lubrication", by Dr H. E. Priston, B.Sc., F.R.I.C., M.Inst.Pet., (Shell-Mex and B.P. Ltd);
"Cutting Oils", by V. G. J. Haden (Shell-Mex and B.P. Ltd);
"Lubrication of Oil Engines", E. Atkinson (Shell-Mex and B.P. Ltd);
"Lubrication of Steam Turbines and Nuclear Equipment", by Dr H. C. O'Connor (Shell-Mex and B.P. Ltd);

Applications for the course should be sent to R. I. Newsome, Department of Civil and Mechanical Engineering, Huddersfield College of Technology, Huddersfield, Yorks, enclosing the fee of 1 guinea.

1960 Piacenza Hydrocarbons Convention

The 5th International Hydrocarbons Exhibition and the 9th National Methane Gas Exhibition will be held at Piacenza, Italy, on 12–18 September 1960, together with the Technical and Economic International Convention on Hydrocarbons.

The exhibitions will feature the latest developments in plant, machinery, and measurement and control instrumentation. Complementary to these displays the Convention will be held on 12–15 September and will include papers dealing with both the technical and economic aspects of natural gas production and utilization. Problems of the co-ordination of the political economy in the field of energy sources will also be discussed.

Applications for admission to both the Convention and the Exhibitions should be made to Ente Manifestazioni Fieristiche Piacentine SpA, Piacenza, Piazza Cavalli 35, Italy. The fee for participation in the Convention is 15,000 lire.

Optical Instruments and Techniques

A conference on Optical Instruments and Techniques is being arranged by the British National Committee for Physics, under the auspices of the International Commission for Optics. It will be held in London during the period 10–14 July 1961. Enquiries should be addressed to K. J. Habell, National Physical Laboratory, Teddington, Middlesex.

Rheological Techniques

The Battersea College of Technology is this winter holding a course of 10 lectures on rheological techniques, to be given by R. W. Whorlow, B.Sc., A.Inst.P.

The course is suitable for physicists and chemists, and will be held on Tuesdays commencing on the 4 October 1960. The emphasis will be on the theory of experimental methods leading to absolute measurements of stress and strain. Examples of instruments and results will be drawn from a wide range of industries.

The fee for the course is £1. Enrolment forms may be obtained from the Secretary (Rheological Techniques Course), Battersea College of Technology, London, S.W.11.

Automatic Control Symposium

A symposium on automatic control is being held in London on 27–28 September 1960, being the British contribution to the First International Congress of the International Federation of Automatic Control held in Moscow earlier this year. In addition to the discussion of papers it is planned to report briefly on major contributions to the Moscow Congress.

Preprints of the British papers will be supplied to those registered to attend the symposium. Lists of papers, and a symposium registration form, may be obtained from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Accident Prevention Training Course

In the autumn the Royal Society for the Prevention of Accidents plans to hold a one-week residential safety training course for safety officers concerned with accident prevention in the building and civil engineering industries.

The course will cover both theoretical and practical aspects of the work, and will include lectures on safety organization, causes of accidents, scaffolding, lifting appliances, and demolitions. It will be held at the Civil Defence Staff College at Sunningdale, Berks, on 13–18 November 1960. The inclusive fee for the course will be £25.

All enquiries should be made to the Training Officer, Royal Society for the Prevention of Accidents, Industrial Safety Division, Artillery Mansions, 75 Victoria Street, London, S.W.1.

Management and Sales Courses

A programme of courses and conferences on management and sales problems has been organized for the forthcoming autumn, by C. Osmond Turner Ltd, 14 Bryanston Street, London, W.1.

Small groups will be engaged on such subjects as building the management team; management communications; increasing sales in the field; and meetings, decision making, and problem solving. The length of the courses are mostly of two or three days, the fees (which include lunches) varying according to subjects from 12–37½ guineas.

International Symposium on Inorganic Polymers

A meeting sponsored by The Chemical Society will be held at the University of Nottingham on 18–21 July 1961. A fuller announcement, indicating the scope of the symposium and giving details of the principal speakers, etc., will be issued in October. This will be published in *Proceedings of The Chemical Society*, and copies will also be sent to those who apply before 1 October 1960 to the General Secretary, The Chemical Society, Burlington House, London, W.1.

World Tanker Statistics Second Quarter 1960

Oil tankers under construction in the world during the second quarter of 1960 totalled 243 ships of 4,358,613 gross tons, according to the recently-published *Lloyd's Register Shipbuilding Returns* for that period. This was a drop of 293,547 tons compared with the previous quarter, and represented 47·8 per cent of the total tonnage of all types of vessel under construction in the world.

The number of steamships under construction totalled 115 of 3,193,508 tons, and the 128 motorships had a tonnage of 1,165,105.

At the end of the quarter 55 tankers of 895,175 gross tons were being built in Britain. This was 95,051 tons less than in the first quarter, and represented 48·0 per cent of the total tonnage under construction in the country.

Britain maintained its position as the leading nation of tanker registrations by a wide margin, with 58 ships of 1,005,484 gross tons. Liberia was again in second place, having 17 vessels of 513,355 tons; third was Norway with 27 of 480,439 tons. Italy succeeded to fourth place over the U.S.A. with 24 of 375,420. Full details can be seen in Table I.

Sweden has taken second place to Britain in the list of countries with tankers under construction, with 19 vessels of 477,210 tons. Italy, second at the last quarter, had 28 ships of 460,420 tons. Among the major tanker-building nations France, W. Germany, and Sweden were the only ones to show increases in tanker tonnage under construction compared with the previous quarter. Table II gives details

TABLE I
REGISTRATION OF OIL TANKERS UNDER CONSTRUCTION AT END JUNE 1960

Country of registration	*No*	*Gross tonnage*	*Country of build*	*No*	*Gross tonnage*
Britain	58	1,005,484	Britain... ...	49	777,175
			Commonwealth	1	21,000
			W. Germany ...	2	50,309
			Italy	2	46,000
			Japan	1	30,000
			Netherlands ...	1	21,000
			Sweden ...	2	60,000
Canada	1	26,970	Commonwealth	1	26,970
Other Commonwealth	4	151,700	Britain... ...	1	18,200
			W. Germany ...	2	76,000
			Japan ...	1	57,500
Argentina ...	2	3,000	Unspecified ...	2	3,000
Belgium ...	1	31,700	W. Germany ...	1	31,700
Brazil	4	28,800	Denmark ...	4	28,800
Denmark ...	6	121,000	Belgium ...	1	13,000
			Denmark ...	5	108,000
Finland ...	1	12,000	Netherlands ...	1	12,000
Formosa ...	2	4,800	Unspecified ...	2	4,800
France	11	260,603	Denmark ...	1	21,500
			France... ...	9	210,103
			Netherlands ...	1	29,000
W. Germany ...	5	88,798	W. Germany ...	5	88,798
Greece	4	62,506	Netherlands ...	3	46,236
			Unspecified ...	1	16,270
Iran	2	66,705	France... ...	2	66,705
Italy	24	375,420	Italy	24	375,420
Japan	17	130,710	Japan	17	130,710
Liberia ...	17	513,355	Belgium ...	1	31,200
			Denmark ...	2	59,600
			France... ...	1	45,400
			W. Germany ...	1	13,713
			Italy	1	22,000
			Japan ...	1	72,190
			Netherlands ...	1	32,000
			Sweden ...	4	116,400
			U.S.A.	3	84,052
			Yugoslavia ...	1	16,300
			Unspecified ...	1	20,500
Netherlands ...	11	189,099	Belgium ...	1	30,000
			W. Germany ...	2	1,499
			Netherlands ...	8	157,600
Norway... ...	27	480,439	Britain	4	77,800
			Denmark ...	1	13,450
			W. Germany ...	5	128,800
			Netherlands ...	2	1,000
			Norway ...	10	135,389
			Sweden ...	5	124,000
Panama... ...	4	95,150	Italy	1	17,000
			Japan	2	54,150
			Sweden ...	1	24,000
Paraguay ...	1	1,250	Japan	1	1,250
Poland	2	26,100	Poland ...	1	12,600
			Yugoslavia ...	1	13,500
Portugal ...	3	19,250	Unspecified ...	3	19,250
Russia (U.S.S.R.)	2	15,930	Finland ...	1	3,330
			Poland ...	1	12,600
Spain	11	131,314	Spain	11	131,314
Sweden ...	6	126,230	Sweden	6	126,230
Turkey ...	1	420	Unspecified ...	1	420
U.S.A.	11	330,580	W. Germany ...	1	16,100
			Netherlands	1	50,000
			Sweden ...	1	26,580
			U.S.A.... ...	8	237,900
Venezuela ...	1	22,000	Britain... ...	1	22,000
Yugoslavia ...	4	37,300	Yugoslavia ...	4	37,300

Of the 243 oil tankers under construction totalling 4,358,613 gross tons, 167 of 2,599,249 are for registration in country of build.

TABLE II

OIL TANKERS UNDER CONSTRUCTOIN AT END JUNE 1960

Country of build	Steam		Motor		Total	
	No	Tons gross	No	Tons gross	No	Tons gross
Great Britain and N. Ireland	27	674,830	28	220,345	55	895,175
Other Comwlth countries ...	2	47,970	—	—	2	47,970
Argentina ...	—	—	2	3,000	2	3,000
Belgium ...	2	61,200	1	13,000	3	74,200
Denmark ...	5	133,100	8	98,250	13	231,350
Finland ...	—	—	1	3,330	1	3,330
Formosa ...	1	20,500	2	4,800	3	25,300
France	8	263,224	4	58,984	12	322,208
W. Germany	12	356,011	7	50,908	19	406,919
Greece	—	—	1	16,270	1	16,270
Italy	17	431,600	11	28,820	28	460,420
Japan	7	272,040	16	73,760	23	345,800
Netherlands ...	9	244,636	9	104,200	18	348,836
Norway... ...	—	—	10	135,389	10	135,389
Poland ...	—	—	2	25,200	2	25,200
Portugal ...	1	17,560	2	1,690	3	19,250
Spain	2	43,000	9	88,314	11	131,314
Sweden	9	269,585	10	207,625	19	477,210
Turkey ...	—	—	1	420	1	420
U.S.A.	11	321,952	—	—	11	321,952
Yugoslavia ...	2	36,300	4	30,800	6	67,100
World total ...	115	3,193,508	128	1,165,105	243	4,358,613

of tankers under construction, their country of build, and type of propelling machinery.

During the second quarter of 1960 Britain commenced 12 tankers, launched 9, and completed 12. Japan commenced 33, launched 29, and completed 30. West Germany commenced 5, launched 13, and completed 10. Italy commenced 7, launched 5, and completed 3. Details of launchings appear in Table III.

TABLE III

OIL TANKERS LAUNCHED DURING THE SECOND QUARTER 1960

Country of build	Steam		Motor		Total	
	No	Tons gross	No	Tons gross	No	Tons gross
Great Britain and N. Ireland	5	98,845	4	27,262	9	126,107
Other British Commonwlth countries ...	1	26,970	—	—	1	26,970
Argentina ...	—	—	1	1,500	1	1,500
Belgium ...	1	30,000	—	—	1	30,000
Denmark ...	—	—	3	41,700	3	41,700
Finland ...	—	—	—	—	—	—
Formosa ...	1	20,500	—	—	1	20,500
France	4	133,454	1	11,852	5	145,306
W. Germany ...	4	119,108	9	46,924	13	166,032
Italy	4	116,300	1	850	5	117,150
Japan	3	112,700	26	52,585	29	165,285
Netherlands ...	1	21,000	3	37,600	4	58,600
Norway... ...	—	—	1	1,850	1	1,850
Poland ...	—	—	1	12,600	1	12,600
Spain	—	—	—	—	—	—
Sweden ...	2	56,580	1	25,800	3	82,380
Turkey ...	—	—	—	—	—	—
U.S.A.	2	54,493	—	—	2	54,493
Yugoslavia ...	1	16,300	2	27,000	3	43,300
World total ...	29	806,250	53	287,523	82	1,093,773

U.K. PETROLEUM EQUIPMENT ORDERS

Orders for materials and equipment placed in the United Kingdom by oil companies during the first quarter of 1960 increased by £854,108 over the figure for the corresponding quarter of 1959.

Increases in value were registered in the following categories. Drums and can-making, filling and cleaning equipment, kerbside pumps, etc. (337 per cent); railcars, road tankers, aircraft refuellers, etc. (163 per cent); tankage, including tank fittings, tubulars, pipe-fittings, and valves; pumps (excluding slush, oilwell, and kerbside); instruments, meters, and gauges; ferrous and non-ferrous plates, sections, sheets, and bars; automotive equipment; laboratory equipment and chemicals; bulk chemicals, catalysts, barytes, etc.; cement and other building materials and hardware; and commissary and general requisites.

The remaining groups declined in value, particularly geophysical and other exploratory equipment (69 per cent); boilers, boiler house plant and accessories (85 per cent); and prime movers and compressors (52 per cent).

Full details are given in the table.

	1960 Jan.–Mar.	1959 Jan.–Mar.
Geophysical and other exploratory equipment, etc.	9,582	30,809
Specialized equipment for oil drilling and production, including oil casing, tubing, etc.	2,401,983	2,756,544
Specialized equipment for oil refineries, etc. (not including pumps and valves)	946,500	1,097,525
Drums and can-making, filling and cleaning equipment, kerbside pumps, and other metering and dispensing equipment, etc. ...	1,548,008	354,432
Railcars, road tankers, aircraft refuellers, etc.	506,092	192,097
Drums, drumsheets, and tinplate ...	1,573,047	2,267,229
Tankage (including tank fittings) ...	1,385,792	973,311
Tubulars, pipe fittings, and valves (ferrous and non-ferrous) ...	3,008,462	2,821,522
Pumps (excluding slush, oilwell, and kerbside)	476,191	398,594
Boilers, boiler house plant and accessories, etc.	109,706	748,797
Electrical equipment—motors, generators, transformers	1,184,695	1,446,510
Instruments, meters, and gauges, etc.	576,395	533,849
Prime movers and compressors ...	389,050	804,838
Machine and hand tools, welding and miscellaneous machinery and stores	1,934,220	3,049,252
Ferrous and non-ferrous plates, sections, sheets, and bars ...	870,794	810,306
Automotive equipment, all types ...	2,412,895	2,300,641
Laboratory equipment and chemicals, including hospital and medical supplies	466,035	372,184
Bulk chemicals, catalysts, barytes, etc.	8,264,672	6,104,923
Cement and other building materials and hardware, including timber...	571,302	531,491
Commissary, general requisites for office, warehouse, household, club and sports, etc.	2,384,842	1,571,301
	£31,020,263	£29,166,155

The First Pipes and Pipelines Exhibition

The pipes and pipelines industry to-day affects the economy of many countries throughout the world. In the non-communist world alone there are now approximately 240,000 miles of oil pipelines and 540,000 miles for the conveyance of natural gas. In addition, there are many thousands of miles of pipeline all over the world for the transport of water and manufactured gas, and the smaller-diameter pipe in use in such installations as oil refineries, chemical plants, etc.

It is said that over the next decade the oil industry alone will spend some £50,000 million on expansion, and replacements of pipelines.

Not only has the range of pipeline materials spread enormously within recent years, and now includes steel, spun iron, non-ferrous metals, asbestos-cement, pitch fibre, plastics, and nylon, but the various manufacturing methods have vastly improved and speeded-up.

Automatic submerged arc welding has replaced the old water gas method of joint welding, whilst the electric resistance weld process is increasing for large-diameter pipes; manual and crane handling has been almost entirely eliminated by the use of conveyors and mechanical handling equipment; the use of a greater variety of special-purpose plant has speeded up operations; production rates have increased by the reorganization and re-equipment of manufacturing installations; and great advances have taken place with the internal and external welding of longitudinal joints. In addition, more efficient and economic methods of pipeline control, with the considerable trend towards automation in such matters, have resulted from the increasing size and complexity of pipeline networks.

In view of this tremendous growth in the use of pipes and pipelines, and the extension of the industry to include several other design and manufacturing technologies, it was decided to publicize these new developments by bringing together as many products as possible in the form of the first Pipes and Pipelines Exhibition.

This was held at Earl's Court, London, on 30 May–2 June last. The interest in the event that was evinced by the industry was shown by the fact that it was necessary to double the stand space originally envisaged.

The following are some of the 120 or so British, European, and U.S. exhibitors, with brief details of their exhibits. Further information should be obtained from the companies concerned.

John Allen & Sons (Oxford) Ltd, Cowley, Oxford.
The Allen Model 140 wheel trencher, powered by a 50 bhp diesel engine, governed at 1250 rev/min. Cutting widths from 17½ to 30 in, and maximum depth of trench 5 ft 6 in. Low ground pressure of only 5·7 psi enables the machine to negotiate soft ground.

George Angus & Co. Ltd, Angus House, Newcastle-on-Tyne 2.
Complete range of rubber industrial hoses in both moulded and wrapped ply constructions. Delivery and suction hoses; oil suction and discharge hose HBS and ASD types; and fire hoses with reinforced rubber linings and impregnated with PVC.

A.P.V.-Paramount Ltd, Manor Royal, Crawley, Sussex.
The Paralloy range of "Forging Quality" cast stainless steel pipe fittings and flanges in corrosion-resisting steels. Interchangeable with forged fittings and flanges to current specifications. Also castings of pipeline, valve, pump, and other equipment.

BTR Industries Ltd, Herga House, Vincent Square, London, S.W.1.
Fluoroflex PTFE-lined pipes and fittings, etc; tees, elbows, couplings, caps, flanges, etc, up to 8-in diameter bore manufactured from *Silverflow* PVC; and pipes, fittings, and valves made from *Kera* phenol formaldehyde resins.

The Compoflex Group, Paddockhall Road, Haywards Heath, Sussex.
Composite air hoses including vacuum cleaner hose, suction and delivery hoses for gasoline, oil, and water. A range of interlock metallic tubing for both pressure and exhaust uses, extended plastic tubing, and *Permabrite* stainless steel tubes and sections.

Gilbarco Ltd, 740 High Road, Tottenham, London, N.17.
Brodie positive displacement meters covering flows of 1–12,000 Imp gal/min. The new Brodie series 500 range of valves, available in sizes up to 12 in, which can be operated mechanically, electrically, pneumatically, and hydraulically.

John Gosheron & Co. Ltd, Albert Embankment, Vauxhall, London, S.E.11.
Technical and printed tapes. Includes *Polyvil* PP tape—extremely tenacious rubber-based adhesive bonded to PVC film. Tropic and arctic grades available, and can be used on irregular contours and surfaces by reason of its pliability. *Vylap* self-bonding PVC tape for above-ground applications in extreme climates or heavily-polluted atmospheres.

Industrial Inspection Ltd, Tavistock House, Tavistock Square, London, W.C.1.
Non-destructive testing equipment, including pipeline isotope set; isotope carrier, torch and saddles; pipeline crawler and flange tester; lightweight x-ray set of 160 kV and 5 mA; portable magnetic crack detector for site work; and eddy current tube tester for non-magnetic metals.

Kellogg International Corp, Kellogg House, 7–10 Chandos Street, Cavendish Square, London, W.1.
Featuring of the Kellogg flexibility analysis service available on a consulting basis to pipeline design engineers. Illustrations of the economic advantages and simplification of the use of pipeline blending in place of tankage, and the problems of passing hot viscous fluids through a long pipeline. Booklet on the use of plastic pipe.

Lincoln Electric Co. Ltd, Black Fan Road, Welwyn Garden City, Herts.
Electrodes for pipeline welding and tankage construction. The new Lincoln SA 200 mobile engine-driven welder powered by diesel engine developing 21 bhp at 2000 rev/min, providing a hand current range of 30–275A. Also the new Lincoln-Cloos type CA3 semi-automatic CO_2 shielded arc welding unit.

Metal Economics (Seaguard) Ltd, Seaguard House, 20 Balcombe Street, London, N.W.1.
Technique (which is new to the U.K.) of blast cleaning and coating steel pipes with the new epoxy coal tars formulated for underground service. Used in all extremes of climate, and the whole process is automated. Pre-packaged joint coating packs supplied for field use.

Metallic GmbH, Wuppertal-Barmen, Western Germany.
Rubber sealing rings for supplying a leak-proof system application; also gaskets, joint runners for concrete, stoneware, cast iron, and steel pipes in many industries.

Murex Welding Processes Ltd, Hertford Road, Waltham Cross, Herts.
Murex metal-arc welding equipment, accessories, and electrodes, and Ross holding and positioning equipment for pipeline work. *Fastex 100* and *Fastex 100M* electrodes for metal-arc vertical downward welding of mild and low alloy steels; *Coilex* electrode for open-arc automatic welding of mild and medium tensile steels; *Muraflex* submerged arc welding flux for mild steel.

Newalls Insulation Co. Ltd, Washington, Co. Durham.
Insulation materials, including the *Newtherm* calcium silicate insulation for land and marine applications, in a wide range of industries.

The North British Rubber Co. Ltd, 62 64 Horseferry Road, London, S.W.1.
Amazon wire cord hose for dock sea loading, and propane and bitumen loading. Hoses for gasoline pumps, aircraft refuellers, suction and water hoses, etc. Rubber fenders for dock facilities, and expansion joints for shipping and engineering installations. Film of the use of rubber river-crossing pipe.

Bruce Peebles & Co. Ltd, East Pilton, Edinburgh 5.
Range of *M-Scope* pipe finding and leak detection equipment. This includes pipe and cable locating and network analysing equipment; metal detectors; *M-Pact-O* rods for making probe holes through concrete, asphalt, or rock-strewn ground; and water level indicators fitted to hand or geophysical-type reels.

Permacel Tapes Ltd, 260 Bath Road, Slough, Bucks.
Ribbon pipe sealant of unsintered PTFE in ribbon form, ½-in width, for application to pipe threads before coupling. Claims are that it is self-lubricating, chemically inert, has a temperature range of −450 to +500 F, and is non-toxic.

The Pitch Fibre Pipe Association of Great Britain, 27 Chancery Lane, London, W.C.2.
All applications of pitch fibre pipe, including a variety of drainage applications, sewage disposal, cable conduit and ducts, and ventilating ducts. Low costs due to reduced excavation, high laying speeds, absence of concreting, freedom from holdups, etc. Pipes available in diameters of 2–6 in and in lengths of up to 10 ft.

Quasi-Arc Ltd, Bilston, Staffs.
Celtian electrodes for the vertical downwards or "stove pipe" welding of pipes, and storage tanks; engine-driven DC *Mobilarc* welding generators with capacities of 300–500A; and the new Quasi-Arc *Basic-Head* which enables a complete automatic welding insulation to be built up from seven basic components—designed primarily for FUSARC CO_2 welding.

Ruston & Hornsby, Lincoln, Lincolnshire.
Range of Ruston-Grayloc high pressure, high temperature, all-metal pipe connexions for standard pipe sizes of 1-30-in diameter for butt weld, socket weld, or threaded connexions.

Simmonds Aerocessories Ltd, Treforest, Pontypridd, Glamorgan.
Simmonds-BP shock alleviator valve, fitted with a 4-in, 150-lb raised face flange, which may be orientated in any manner on installation. *Fram* two-stage separator-filters for aviation fuel installations. Simmonds solenoid-operated stop valve; special strainers of 2–24-in diameter, fabricated in mild steel; and the *Fram* mild steel filter for lubeoil and fuel oil applications at flow rates of 400 Imp gal/min against a pressure drop of 0·8 psi.

Simmons & Hawker Ltd, North Feltham Trading Estate, Central Way, Feltham, Middlesex.
Welded pressure vessels, heat exchangers, and fabricated pipework. Pipe fittings, pipe coils, expansion joints, filters, strainers, and separators, etc. Structural steelwork for loading gantries, valve access and operating floors.

Triangle Valve Co. Ltd, 315–317 Regent Street, London, W.1.
Valves in drop forged, cast, and stainless steel and cast iron. Through conduit pipeline double disk, lubricating plug, wedge gate, parallel slide, line blind "Y" valves, etc. Sizes of ¼–36 in, and pressure range 125–1500 psi.

Wailes Dove Bitumastic Ltd, Hebburn, Co. Durham.
Various grades and applications of *Bitumastic* coatings for the protection of gas, oil, and water pipes. Detailed instructions given for the proper handling and application of the enamels and their relevant priming solutions.

Wavin Pipes Ltd, Cian Park, Drumcondra, Dublin.
Wavin lightweight rigid PVC pipes (shown for the first time in the U.K.). Inert to most known chemicals, and immune to corrosion. Service and distribution pipes in sizes ¾–1½ in with complete range of PVC fittings; thick wall industrial pipes and fittings of ½–2 in; and rigid PVC electrical conduit and fittings.

Wilmot Breeden Ltd, Goodman Street, Birmingham.
Products (including those of the associate company, Telehoist Ltd) covering the *Telesig* positive displacement screw pump; *Velflo* circular ducting fittings for high-velocity air conditioning, etc; and *Truflo* stainless steel and alloy butt-weld thin-wall piping fittings.

Woodfield Rochester Ltd, Frindsbury Works, Rochester, Kent.
Featuring, with animated model, of the Woodfield flow boom system of loading and unloading of tankers of 2000–130,000 tons capacity, allowing for a manifold rise and fall of 85 ft. Boom sizes 8, 10, 12, and 16-in nominal bore. Also *Act-on* quick-change pipe unions of both threaded and welded types, and a complete range of oilfield rigs, masts, mud systems, production equipment, etc.

Yorkshire Imperial Metals Ltd, PO Box 166, Leeds.
Tubes in copper, brass, and a wide range of copper-case alloys, for pipes and pipelines. Pipe fittings, and polythene and PVC-covered copper tubing for gas and water service. Copper pipes up to 20-in o.d.; *Yorcalbro* (aluminium-brass) and *Kunifer* 5 (copper-nickel-iron) pipes of up to 18-in bore.

It has since been announced that the exhibition was such a success that preparations have already commenced for the Second International Pipes and Pipelines Exhibition. It will be held at Earl's Court in the week of 10–15 April 1962, and in conjunction with it a technical convention will be organized.

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CHEMICAL SOCIETY ANNIVERSARY MEETINGS

The scientific proceedings at the Society's anniversary meetings to be held in Liverpool from 11–14 April 1961, will be divided between two sections meeting simultaneously. Within each section, there will be three sessions of lectures and papers. The topics to be discussed and the names of those who have provisionally accepted invitations to contribute appear below.

Section A. **Developments in the Chemistry of Boron Compounds**

A. B. Burg (*University of Southern California*), D. B. Clapp (*Borax Consolidated Ltd*), A. G. Davies (*University College, London*), W. Gerrard (*Northern Polytechnic, London*), N. Greenwood (*University of Nottingham*), A. K. Holliday (*University of Liverpool*), R. Köster (*Max-Planck-Institut für Kohlenforschung, Mülheim/Ruhr*), M. F. Lappert (*College of Science and Technology, Manchester*), H. Steinberg (*U.S. Borax & Chemical Corp*), H. S. Turner (*Chemical Research Laboratory, Teddington*).

Section B. **Some Aspects of the Chemistry of Natural Products**

Newer applications of physical methods

C. Djerassi (*Stanford University, California*), L. M. Jackman (*Imperial College of Science and Technology, London*), R. I. Reed (*University of Glasgow*).

Photochemical transformations

D. H. R. Barton (*Imperial College of Science and Technology, London*), G. Büchi (*Massachusetts Institute of Technology*), W. G. Dauben (*University of California*), E. Havinga (*University of Leiden*).

Porphyrins and related compounds

V. M. Clark (*University of Cambridge*), A. W. Johnson (*University of Nottingham*), G. W. Kenner (*University of Liverpool*).

Abstracts will be circulated in advance to participants, but it is not intended to publish a detailed report. Various excursions and visits have been arranged, some of special interest to ladies. The final programme and application forms will be distributed in December.

Trade Literature

The Choice and Use of Fuel Oils in Heating Appliances

In conjunction with their fuel oil distributors, Charrington, Gardner, Locket (London) Ltd and Associated Coal and Wharf Companies Ltd, Mobil Oil Company has produced three booklets on the subject of fuel oils.

The first booklet *The Use and Storage of Fuel Oils* outlines the general principles of application, discussing the factors that are of special importance when the type of plant and the grade of fuel oil best suited to a particular requirement are being determined, and covers a wide range of space-heating and steam-raising applications.

Steam and Hot-water Boiler Testing explains the necessity for boiler testing, either during acceptance tests of newly-installed plant or during periodical tests to check the efficiency of operating plant. The booklet explains the test equipment and techniques which should be used, and how they can be applied to both steam and heating boilers.

Finally, *Fuel Oil Analysis* explains the composition and classification of fuel oils and the significance of their characteristics with respect to fuel oil combustion. Such characteristics as viscosity, calorific values, specific gravity, pour point, distillation, flash point, water, sediment, ash and sulphur content, carbon residue, and the carbon/hydrogen ratio are defined and the normal methods of test are explained. A final section describes the type of equipment suitable for each grade of fuel.

Mechanical Seals on Milford Haven Pipeline

The four centrifugal pumps on the 18-in pipeline from Angle Bay to BP's Llandarcy refinery are fitted with Flexibox mechanical seals, manufactured by Flexibox Ltd, Nash Road, Trafford Park, Manchester 17.

The pumps concerned are Hayward Tyler 8 × 10 × 16-in single-stage, Type OPL horizontal spindle centrifugals, designed to run at 2950 rev/min with stuffing box pressures in excess of 500 psig. Either two, three, or all four of the pumps can be operated in series to deliver up to 3290 Imp gal/min against differential heads up to 915 psi, and each pump is fitted with two Flexibox balanced mechanical seals type RRNCQ80.

Transportation of Equipment for Milford Haven Refinery

Two automatic control boards—both over 30 ft long—were recently completed by Simplex Electric Company Ltd, Blythe Bridge, for Esso Petroleum Co's. new Milford Haven refinery. In both cases, the intricacy of the construction and wiring of the completed boards could not be broken down, and they had to be loaded as complete units for their transportation by road to the site, as can be seen in the upper photograph.

On the boards, Simplex S & S direct-on-line motor starters will control the agitators and valves associated with modern oil tanker unloading equipment.

Immediately above the end busbar chambers on both boards, provision has been made for fitting transformers for auxiliary supplies. These will be controlled by the ready-mounted Simplex Star switch fuses. Items of equipment for the Milford haven refinery which were also transported by British Road Services were Powerformer reactors, transported from Swansea Docks. Only one route was available owing to the weight and the height of the load. Even then, one low bridge could be negotiated only by removing the chain securing the vessel to obtain that extra inch or two necessary to get the reactor beneath it. The two 92-ton vessels, seen in the lower picture, were 44½ ft long and 13½ ft high.

Geological Equipment Catalogue

A new catalogue of geological laboratory and field equipment has been issued by Cutrock Engineering Co. Ltd, 35 Ballards Lane, London, N.3. The range included is comprehensive, whilst individual machines can be designed and manufactured for special needs to customer requirements.

New-Type Seal in Valve

The Mission Manufacturing Company has announced the availability of its *Duo-Chek* valve that fits between flanges, and features new concepts in sealing and is an average of 90 per cent smaller than any other check valve of similar pipe size.

The sealing material is moulded into a groove in the plate, making an O-ring type seal. The *Duo-Chek* is adaptable to uses in all types of oil and chemical process plants and for refrigeration, heating, and ventilation.

Additional details are obtainable from the Mission Valve and Pump Company, PO Box 4209, Houston, Texas.

Electronics Constructional Outfit

The first "do it yourself" electronic constructional outfit has been produced to enable pupils to assemble for themselves a large number of experiments and demonstrations illustrating many of the fundamental principles of electronics.

The "Mechtronics" apparatus, which is a joint product of Griffin & George Ltd, Ealing Road, Alperton, Middlesex and Clarke-Smith Mfg. Co. Ltd, dispenses with the need for soldered joints, and the assemblies are screwed or clipped together on a pegboard layout.

The complete set, type 97–100, contains valves, transistors, a photo-electric device, transformer, relay loudspeaker, circuit board, neon tube, crystal diode and potentiometers, bulbs, holders, switch parts, special connectors, wires, valve holders, resistors and capacitors etc.

New Flexible Coupling

R. & J. Dick Ltd, Greenhead Works, Glasgow, S.E., has introduced a new type of flexible coupling, *Quadriflex*, which will provide dependable power and withstand all types of misalignment and end float.

The design consists of two flanges and a two-piece flexible rubber sleeve. The teeth of the sleeve halves lock into the teeth of the flanges without clamps or screws and tighten under torque to provide smooth transmission of power.

Single-Ship Marine Seismic Operations

A three-colour, six-page booklet describing facilities for conducting single-ship marine seismic operations has been published by Geophysical Service Inc, a Texas Instruments company. It stresses the advantages of using for such operations a sizeable sea-going vessel which can proceed anywhere under its own power and does not need to return to port for additional supplies. The bulletin describes GSI's 405-ton motor vessel *Sonic*, and the *Texin*, a 420-ton vessel recently purchased by GSI, both of which can work in any water depth through the use of auxiliary launches equipped with seismic instruments.

Details are also given of the Company's multiple analyser eliminator (MAE), which is intended to eliminate the "singing" phenomena which masks valid reflections from depth, and other GSI seismic and navigational instruments.

Copies of the booklet, Bulletin 560–1, are available on application to Geophysical Service Inc, Marketing Department, 900 Exchange Bank Buildings, Dallas 35, Texas.

Hydraulic Oils

Hydraulic Oils is the title of a 74-page handbook just published by Wakefield-Dick Industrial Oils Ltd.

This book, which contains 50 illustrations, will be a most useful addition to the bookshelf of any engineer concerned with the design, installation, operation, or maintenance of hydraulic equipment. Students, too, should find the many graphs and formulae extremely helpful.

It includes chapters on fundamental hydraulic principles; hydraulic systems, pumps, and components; and hydraulic fluids.

Copies of *Hydraulic Oils* are available, free on request to Wakefield-Dick Industrial Oils Ltd, Castrol House, Marylebone Road, London, N.W.1.

Synthetic Rubber Plant Opened in N. Ireland

The Maydown Works of the Du Pont Company (United Kingdom) Ltd, built to produce neoprene synthetic rubber, was officially opened on 26 July by HE the Lord Wakehurst, Governor of Northern Ireland. Although the plant has been designed for production of 50 million lbs of neoprene a year, plans for a 20 per cent increase in capacity has been announced. Production of neoprene at the Maydown Works not only means a substantial reduction in its importation to the U.K. but also provides an additional source of income to the country through export.

Construction on the 365-acre site was started early in 1958, and 95 per cent of the construction materials and equipment used in the plant, totalling about £4 million, was purchased in the U.K. There are four major production areas, and eight major auxiliary facilities including an administration building, a canteen, engineering shops, stores, a warehouse, a change house, a medical centre, and a quality control laboratory.

Honeywell Controls Described

A selection of brochures recently issued by Honeywell Controls Ltd, Ruislip Road East, Greenford, Middlesex, give a good impression of the range of its automatic control equipment.

Low pressure hot water heating systems; control systems for tempered ventilating plant; and the modes of automatic control and the types of equipment available, are described in separate publications with graphs and descriptive flow charts. An additional "ABC" booklet provides an amusingly light-hearted introduction to the subject.

Mobil Oil for Kariba Turbines

The photograph, taken during the construction of the Kariba Dam, shows the first delivery of Mobil DTE oil heavy medium to the turbine generating sets. About 31,000 gallons will be delivered in all. There are six turbines which are being brought into operation at five-monthly intervals, the last being scheduled to come into operation at the end of 1961. For each turbine, the road tanker has to make two journeys from Salisbury, 250 miles away.

"Modular" Construction for Electronic Instruments

Simpler servicing and lower maintenance costs are claimed in a new range of Honeywell ElectroniK instruments constructed on the "modular" principle.

All major electrical components are contained in four separate quick-change sub-assemblies (modules): constant voltage unit, measuring circuit unit, a sectionalized balancing motor, and quick release amplifier. All these, except the measuring unit, may be incorporated into existing ElectroniK instruments.

Further details are available from Honeywell Controls Ltd, Ruislip Road East, Greenford, Middlesex.

Industrial Electric Surface Heating

Representatives of the technical press recently visited the Boreham Wood works of Isopad Ltd, where they inspected items in the company's range of electric surface heating appliances.

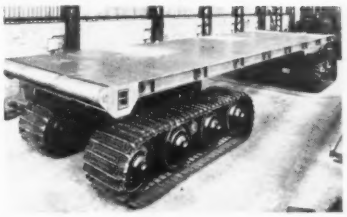
Isomantles electric heating mantles of 5 ml to 200 litre capacity are used in laboratory and glass plant. The heating surface is made from glass yarn, withstanding temperatures of up to 550 C, and the mantles are used for liquid temperatures of up to 350 C.

Run at "black heat", the *Isomantles* transfer the heat to the liquid partly by radiation and partly by conduction, ensuring uniform heat transfer. The heating element incorporated in the glass cloth is fully insulated, and placed in such a manner that both heat and voltage gradients between the elements are kept to a minimum.

For higher temperatures quartz yarn is used instead of glass fibre, enabling the mantles to be used for liquid temperatures up to 600 C.

Isopad electric surface heating is also used in many other industries, from paint works to atomic power plants, for a wide variety of applications such as for mixing and process vessels, columns, pipelines, drums, pumps, and valves.

Trailers with Change-Over Bogies



Two high floatation fully-tracked trailers for use in swamps, which can be converted on the spot to conventional road transport by the fitting of rubber-tyred bogies, were shipped from the U.K. recently to Port Hardcastle for use by Shell-B.P. Petroleum Development Company of Nigeria Ltd.

They are standard 28-ton oilfield trailers adapted to the design of Shell engineers by Dyson Ltd of Liverpool, using specially-designed tracked bogies by J. A. Cuthbertson Ltd of Biggar, Scotland.

The rear bogie arrangement is readily removable, and can be fitted with either a fully-tracked bogie or a conventional rubber-tyred bogie. When operating on their tracked equipment in the swamps, the trailers will be towed by either Cuthbertson Water Buffalos or Caterpillar D8 Tractors, and under normal road conditions, the trailers will be drawn by Scammel Constructor tractor units.

"What Kestners Make"

Under this title the Kestner Evaporation & Engineering Co. Ltd has recently issued a pocket-size reference book giving in some detail information concerning the wide variety of the processes, the plants, and the materials of construction which they produce. The scope is wide, and process engineers and others interested are invited to write for a copy to the Company at 5 Grosvenor Gardens, London, S.W.1.

Hydronyl Sales Contract

The Hydronyl Syndicate Ltd has been entrusted by Imperial Aluminium Company Ltd with the sale of ALCOA tabular alumina products for the chemical, petroleum, petrochemical, and allied industries. Enquiries should be addressed to 14 Gloucester Road, London, S.W.7.

Castrol 98 for the Rolls-Royce Avon

The Air Registration Board and Rolls-Royce Ltd have given full approval for the use of Castrol 98 gas turbine lubricant in the Avon engine.

This follows extensive laboratory, rig, and bench tests as well as flight trials in "Caravelle" aircraft of Air France, powered by Avon Mk 522 engines.

New Phenol Process for Small Plants

A new process for the manufacture of phenol as a result of a research effort to find a new process with a low capital investment and absence of by-products for sale, and which would therefore be particularly suitable to smaller package plant installation, is announced by Scientific Design Co. Inc, 2 Park Avenue, New York 16, N.Y. It makes possible the direct oxidation of benzene to phenol, whose commercial manufacture on a small scale is difficult with existing processes, usually involving disposal problems of important by-products such as salt cake, acetone, etc.

Data Acquisition and Monitoring Equipment Film

A 16-mm colour film with a running time of 20 minutes has been produced by De Havilland Propellers Ltd, Hatfield, Herts, featuring the Company's data acquisition and monitoring equipment.

The equipment has been designed to initiate, measure, record, and monitor signals or operations in a process plant or in any complex system. The film is available for loan to any interested organization.

Elco Report on Grease Additives

A new technical bulletin published by the Elco Lubricant Corp, entitled "Laboratory Evaluation of SCL and other Grease Additives", shows a comparison of SCL, sulphur saponifiable-lead naphthenate, and MIL-L-002105A additives.

All data is reported in detail and includes photographs showing moisture corrosion test comparisons.

Copies of Lube Report No 101 are available from Technisol Ltd, 3 Ridge End, Hook Hill Lane, Woking, Surrey.

India's First Synthetic Rubber Plant

The contract to build India's first synthetic rubber manufacturing plant near Bareilly, Uttar Pradesh, has been awarded to the Lummus Company.

The Lummus Company Ltd, of London, will direct the $30 million project for Synthetics and Chemicals Ltd, a company formed recently by the Firestone Tire & Rubber Company and Kilechand Devchand and Company Private Ltd, a Bombay banking and industrial firm. Construction work on the project will commence within several months. The contract calls for units to produce butadiene and styrene, and a copolymer plant to manufacture the synthetic rubber.

Although the plant will be designed for an initial annual capacity of 20,000 tons, it will be capable of rapid expansion to 30,000 tons.

The financing of the project will be assisted by a $8,250,000 loan from the Export-Import Bank of Washington—the largest foreign currency loan in the bank's history. Operation of the synthetic rubber manufacturing plant is expected to save India about $10 million in foreign exchange annually.

Elliott to Exploit "Shell" Quality Control Instruments

Elliott-Automation Ltd, 34 Portland Place, London, W.1, has entered into an agreement with Hallikainen Instruments, of Berkeley, California, under which they will exploit in the eastern hemisphere (except for Japan) the range of automatic analytical control instruments developed by the Shell Research Laboratories at Emeryville, California, and manufactured under licence by Hallikainen.

The instruments covered by the agreement are mainly for the "in-line" control of processes by continuous measurement of viscosity, vapour pressure, distillation points, specific gravity, and colour analysis.

A new Elliott-Automation subsidiary company, Hallikainen Instruments Ltd, is being formed in London to handle the new business.

Castrol Lubrication Chart

The latest in the series of Castrol lubrication charts covers the Rover 80 and 100 models. Copies are available free on request to Castrol Chart Library, Castrol House, Marylebone Road, London, N.W.1.

ICI Plastics Project in Argentina

Industrias Quimicas Argentinas "Duperial" SA—a subsidiary of ICI—is to build a polythene plant in Argentina.

The plant, which will be financed by the parent company, will cost £5¾ million. It will have an initial capacity of 10,000 tons/year, and will be built on the outskirts of San Lorenzo. Duperial will use the ICI high-pressure polymerization process based on ethylene. They will obtain their raw material by cracking an indigenous light petroleum distillate.

News of this petrochemical project in Argentina comes less than a year after ICI's announcement that Duperial was to spend £2,350,000 on developing a new industrial site at San Lorenzo, some 200 miles north of Buenos Aires on the Parana River. On this site plants will make sulphuric acid and a number of other chemicals for which there is a growing demand in Argentina.

Merging of Two Investment Companies

The Cambridge Investment Co. Ltd, Cambridge House, Grosvenor Place, London, S.W.1, has acquired the assets of Electronic Investments Ltd, Richmond, Surrey.

The basis of the amalgamation is the allotment of 7 fully-paid ordinary shares of 5s each in the Cambridge Company for every three ordinary share of £1 each fully paid in Electronic Investments Ltd.

The latter company will continue to operate under its own name. It operates 2 factories in Richmond and has associated companies in France, Canada, and Australia.

* * *

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Forthcoming Meetings

THE INSTITUTE

(*At* 61 *New Cavendish Street, London, W.*1, 5.30 *p.m.—tea* 5 *p.m.*)

Synthetic Lubricants for Gas Turbines. J. S. Elliott, M.A., and E. D. Edwards, B.Sc. **5 October**

IP FAWLEY BRANCH

(*At Esso* (*Fawley*) *Recreation Club, Holbury*, 7.30 *p.m.*)

Diesel Traction. M. R. Pearson, A.M.I.E.E. **5 October**

LONDON BRANCH

(*At* 61 *New Cavendish Street, London, W.*1, 6 *p.m.—tea* 5.30 *p.m.*)

Industrial Market Research. W. R. Everard, B.Sc. (Econ.). **20 September**

IP NORTHERN BRANCH

(*At Engineers' Club, Albert Square, Manchester* 2, 6.30 *p.m.*)

Bulk Transportation of Petroleum. G. A. Parry. **18 October**

IP SCOTTISH BRANCH

(*At the North British Hotel, Princes Street, Edinburgh*, 7.30 *p.m*

The Petroleum Industry's Role in World Car Market Developments. K. E. W. Ridler, Ph.D., F.Inst.Pet. **6 October**

IP SOUTH-EASTERN BRANCH

(*At the Kings Head Hotel, Rochester*, 7.45 *p.m.*)

Synthetic Fabrics. T. A. Mauder. (Ladies Night). **4 October**

IP SOUTH WALES BRANCH

Visit to Steel Co. of Wales, Velindre. **28 September**

(*At the Training Centre, BP Refinery* (*Llandarcy*) *Ltd*, 5.30 *p.m.*)

The Mechanization of the Postal Services. C. T. Lamping, A.M.I.E.E. **20 October**

IP STANLOW BRANCH

(*At Lobitos Sports Club, Ellesmere Port*, 8 *p.m.*)

Industrial Engineering in an Oil Refinery. W. M. Hare, A.M.I.Mech.E. **23 September**

(*At Lecture Theatre, Grosvenor Museum, Chester*, 7.30 *p.m.*)

Motor Gasoline—Road Testing. J. G. Sharp, B.Sc. (Eng), A.M.I.Mech.E., A.F.R.Ae.S. **19 October**

IP YORKSHIRE BRANCH

(*At Great Northern Hotel, Leeds*, 7 *p.m.*)

Trackways to Motorways. R. P. Bell. **12 October**

* * *

Situation Vacant

CHEMIST PHYSICIST 30-35 for oil works laboratory in North Midlands. Knowledge of structure, properties, and behaviour under varying conditions of light and heat, of vegetable, animal, and mineral oils, greases and waxes. Also an understanding of the effect on friction and flow in connexion with metals and fibres would be useful. State age, family background and responsibilities, general and scientific education, business experience, when available, and some indication of salary required. Box No. 1132, *IP Review*.

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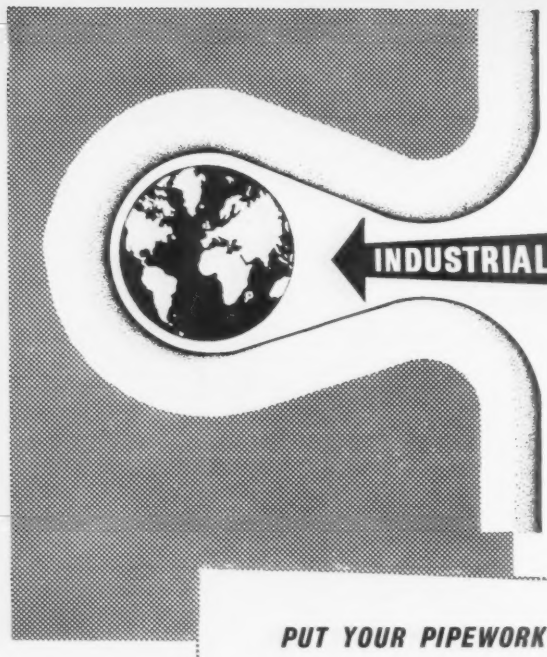

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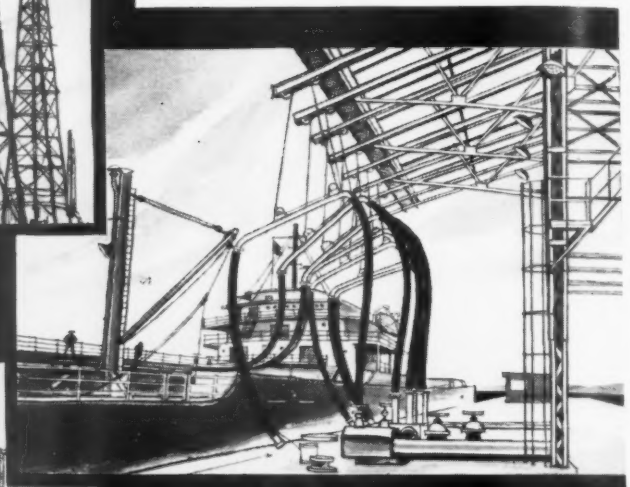

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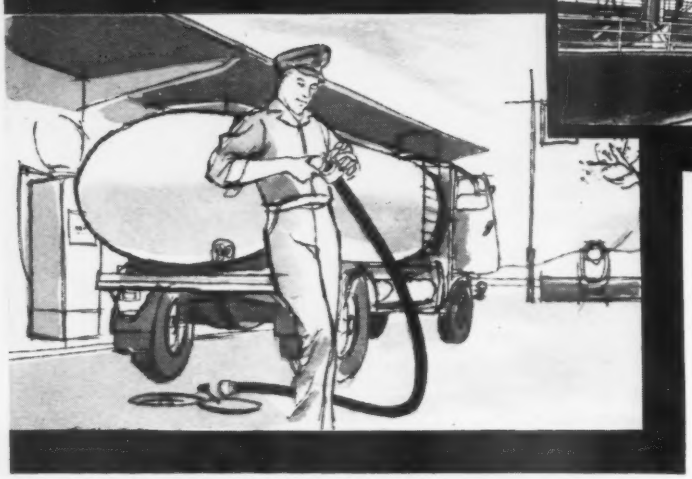

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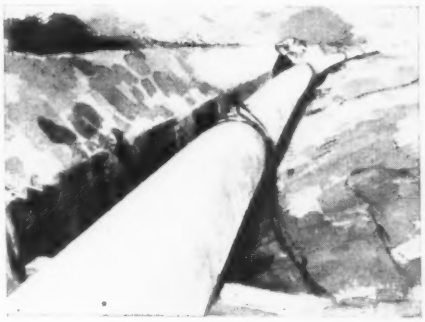

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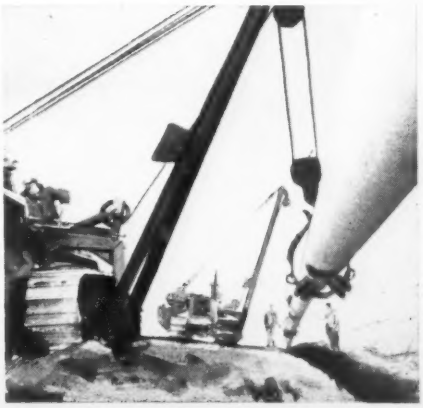

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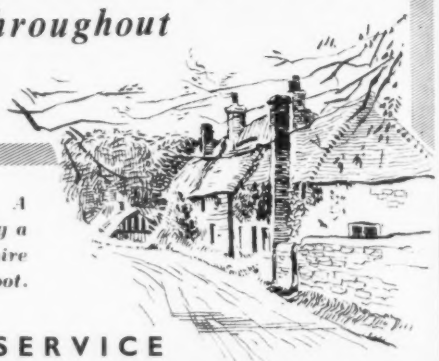

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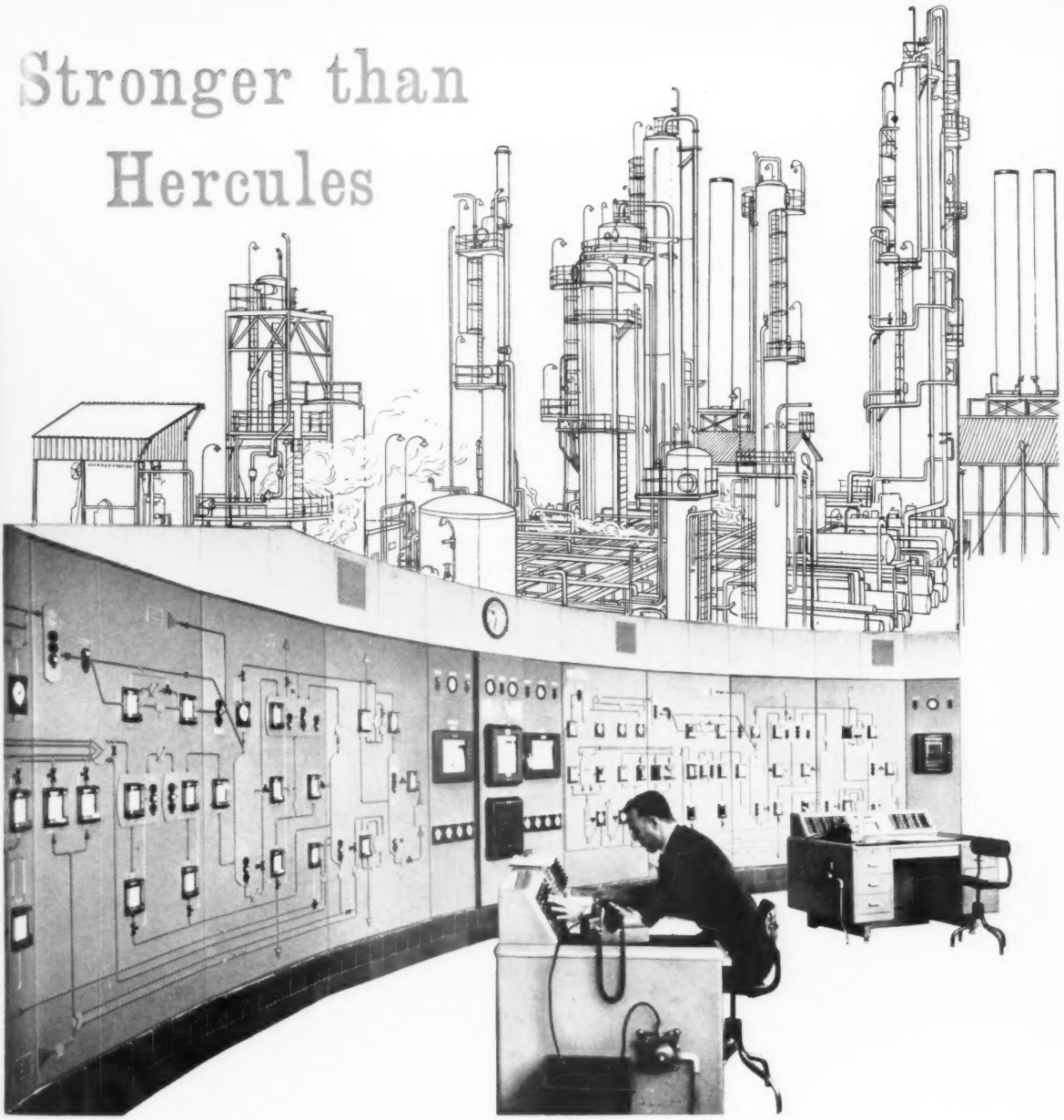

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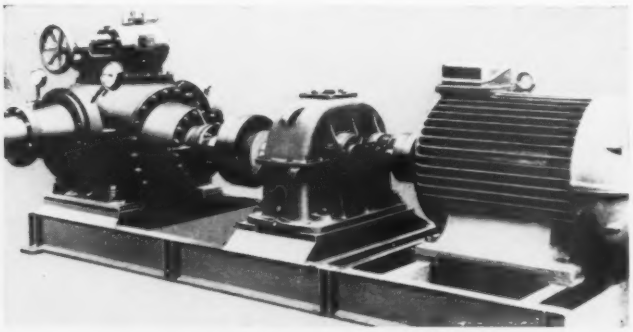

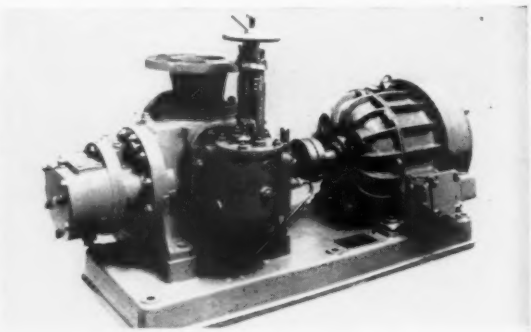

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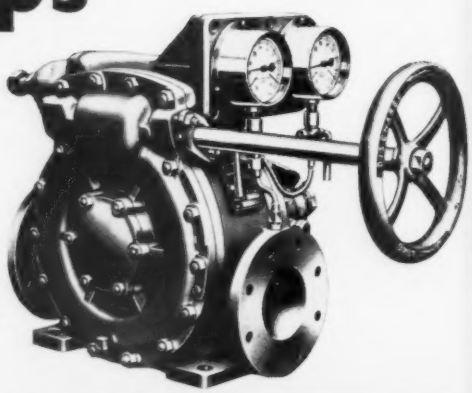

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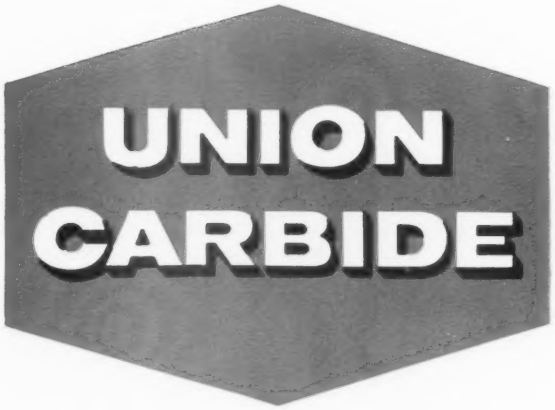

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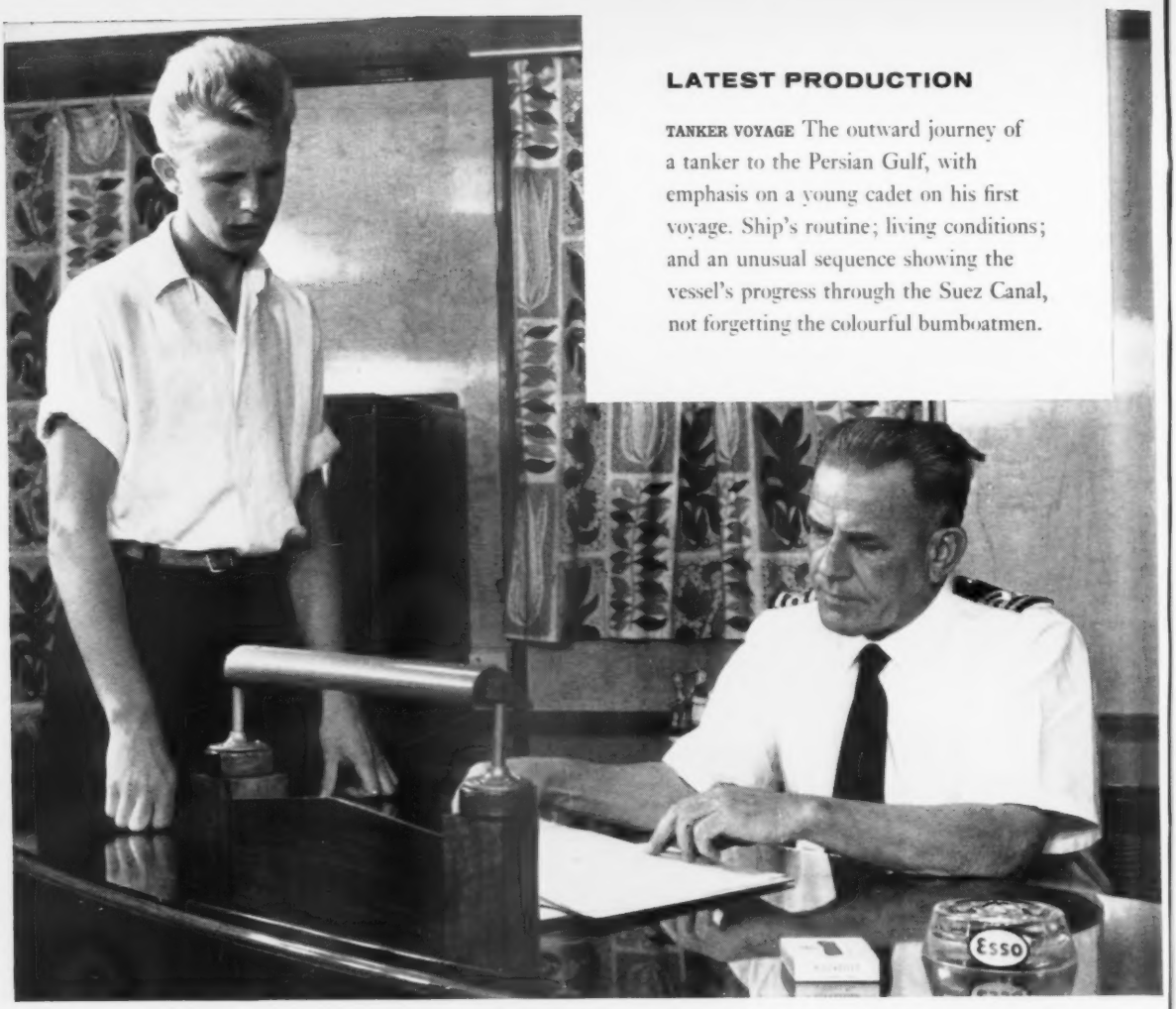

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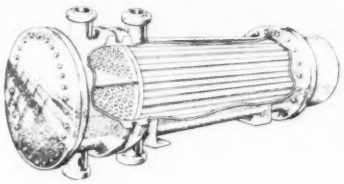

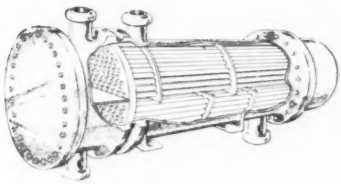

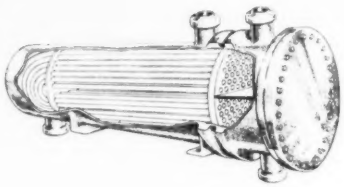

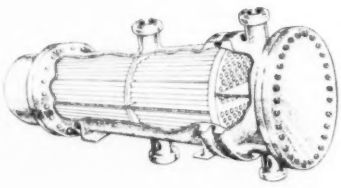

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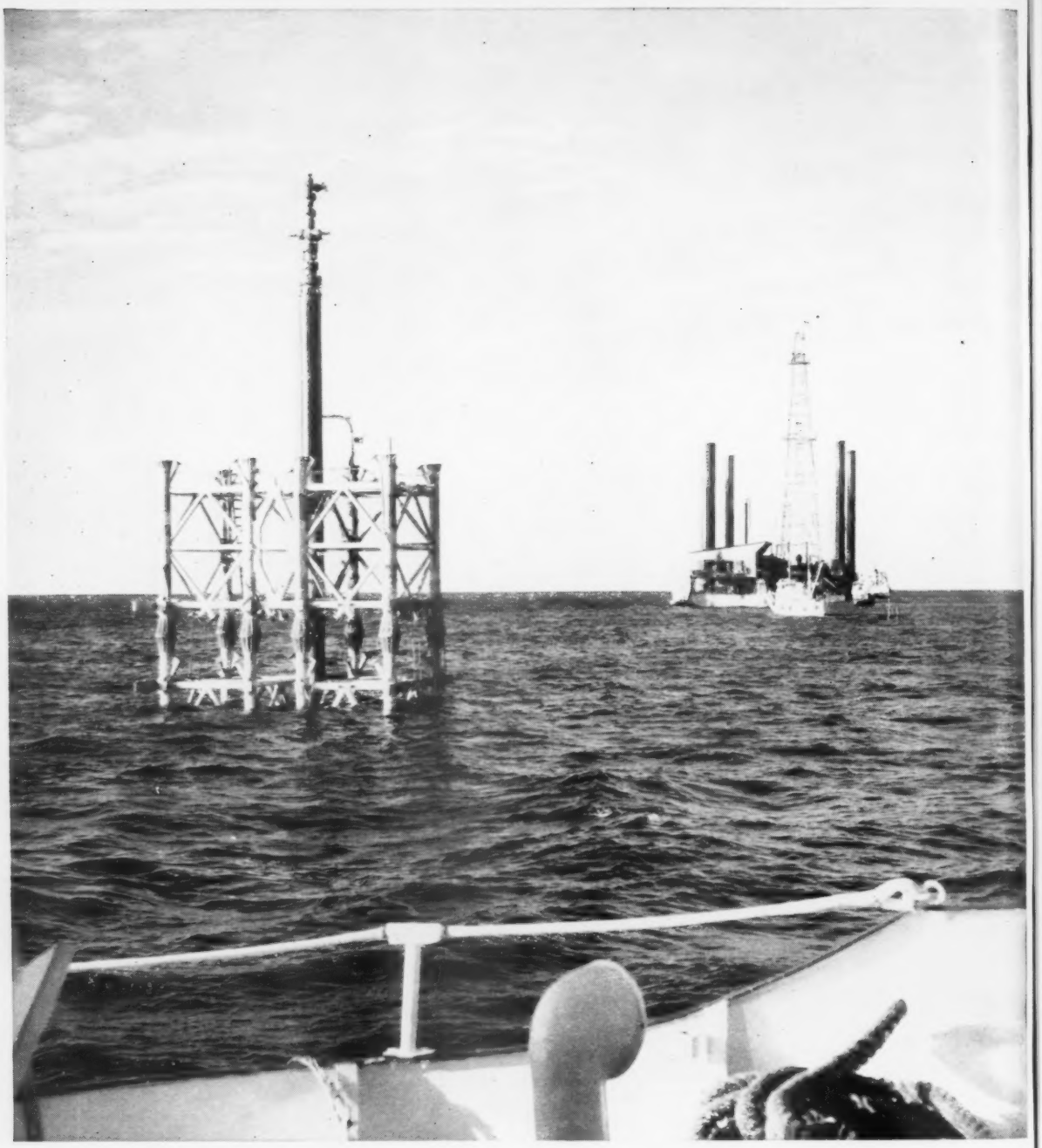
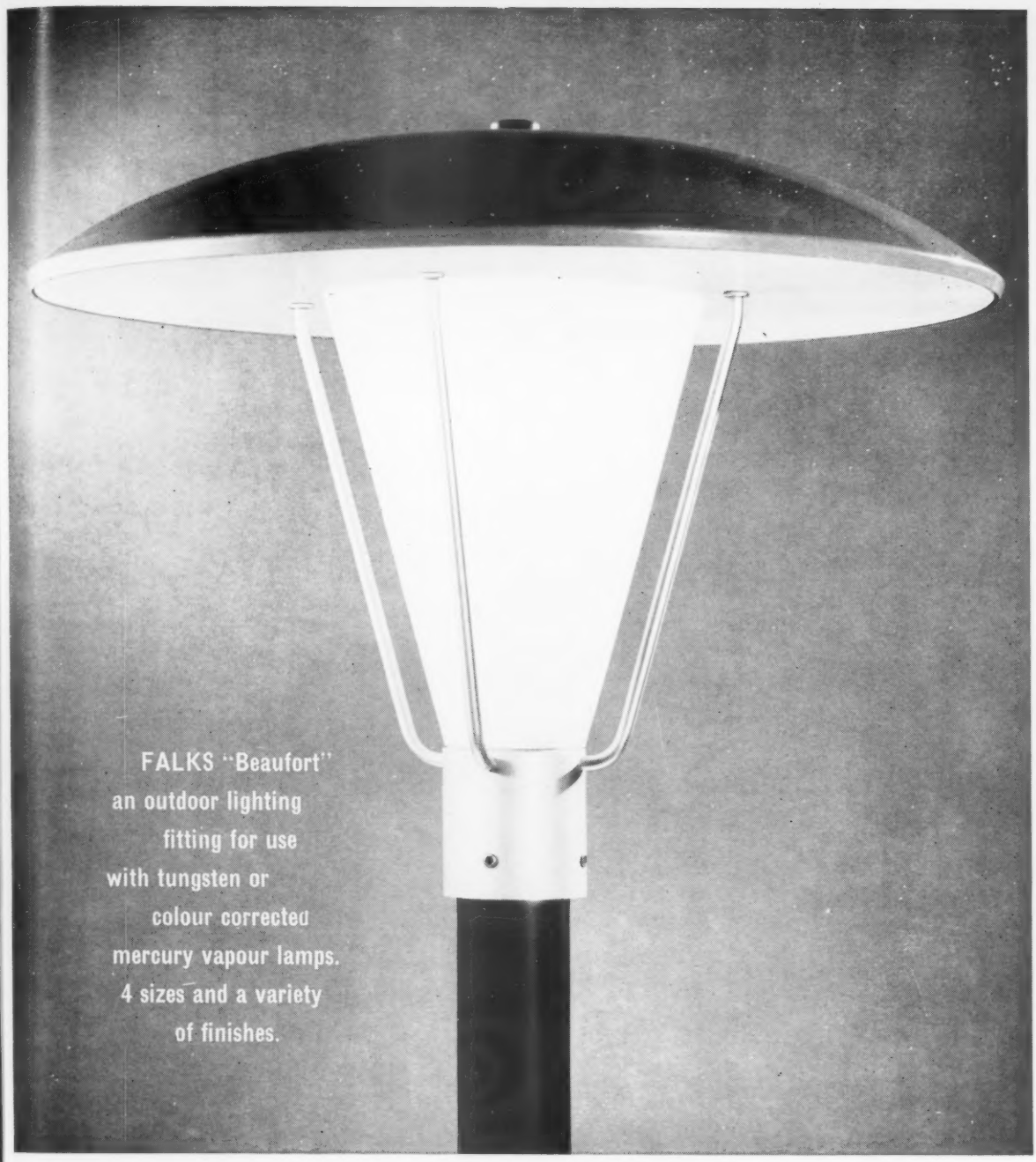


ABU DHABI

A well head in the Persian Gulf. In the background, the barge "Adma Enterprise" which is currently drilling beneath the waters of the Gulf. The results are sufficiently encouraging to warrant the preparation of facilities for regular production. This stage should be reached by mid-1962.

BP



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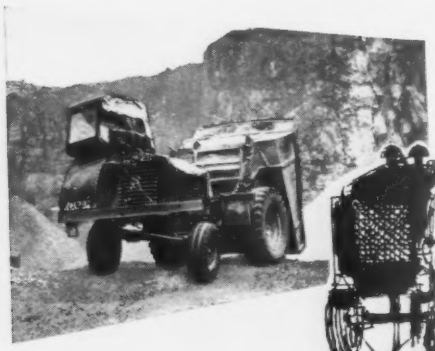

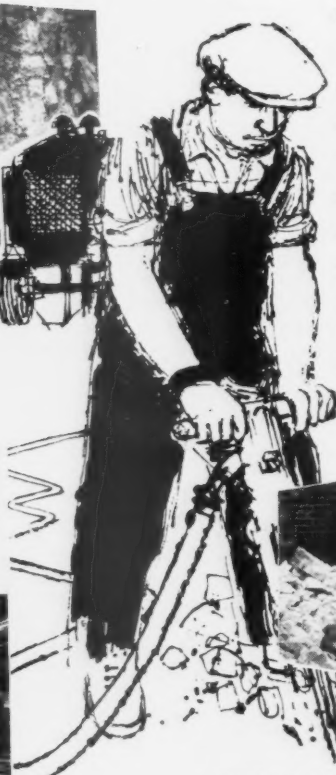

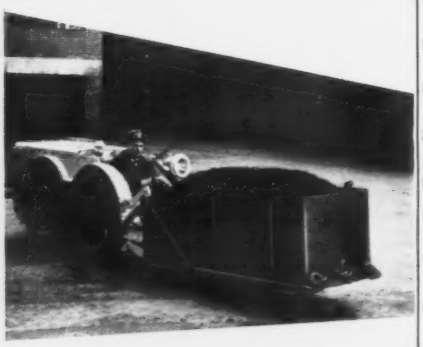

PERKINS INDUSTRIAL ENGINES

TYPE	No. of Cyls.	Bore (ins.)	Stroke (ins.)	Swept Volume (cu.ins.)	Rating	R.P.M GROSS B.H.P.							
						1000	1200	1500	1800	2000	2400	3000	3600
Four 99(I)	4	3	3½	99	A	10.5	13.5	18	22	24.5	29	34	—
					B	12	15	20	24.5	27	32	38	—
					C	12	15.5	20.5	25	27	33	39	43
P3/144(I)	3	3½	5	144	A	16.5	20.5	25.5	30	33	—	—	—
					B	18.5	22.5	28	33	36	—	—	—
					C	18.5	23	29	34	37	42	—	—
Four 203(I)	4	3·6	5	203	A	25	30	38	44	47	—	—	—
					B	27.5	33	41	48	52	—	—	—
					C	28	34	43	50	54	60	—	—
Four 270 (I)	4	4½	4½	270	A	33	39	47	53	57	—	—	—
					B	36	43	52	58	62	—	—	—
P6(I)	6	3½	5	288	A	34	41	51	60	65	—	—	—
					B	37	45	56	66	72	—	—	—
					C	38	46	58	69	75	83	—	—
Six 305	6	3·6	5	305	A	37	44	55	65	71	—	—	—
					B	40	49	61	72	78	—	—	—
					C	41	50	62	74	80	87	—	—
R6(I)	6	4	4½	340	A	38	46	58	67	69	—	—	—
					B	41	51	64	73	76	—	—	—
					C	44	54	68	81	89	102	—	—
S6(I)	6	4¾	5	450	A	49	62	80	96	105	—	—	—
					B	54	68	88	106	115	—	—	—
					C	56	70	90	108	119	—	—	—

REMARKS

A. Denotes continuous rating to BS 649: 1958 conditions (85°F. and 29·5 hg). For every 10° above 85°F. this rating should be reduced by 2% and for every 1000 ft. above 500 ft. altitude the rating should be reduced by 3½%.
B. Denotes one hour rating to BS 649: 1958 conditions. See notes above re de-rating.
C. Denotes intermittent industrial rating to 60°F. and 30 ins. hg conditions. Similar de-ratings should be made for temperature and altitude conditions.

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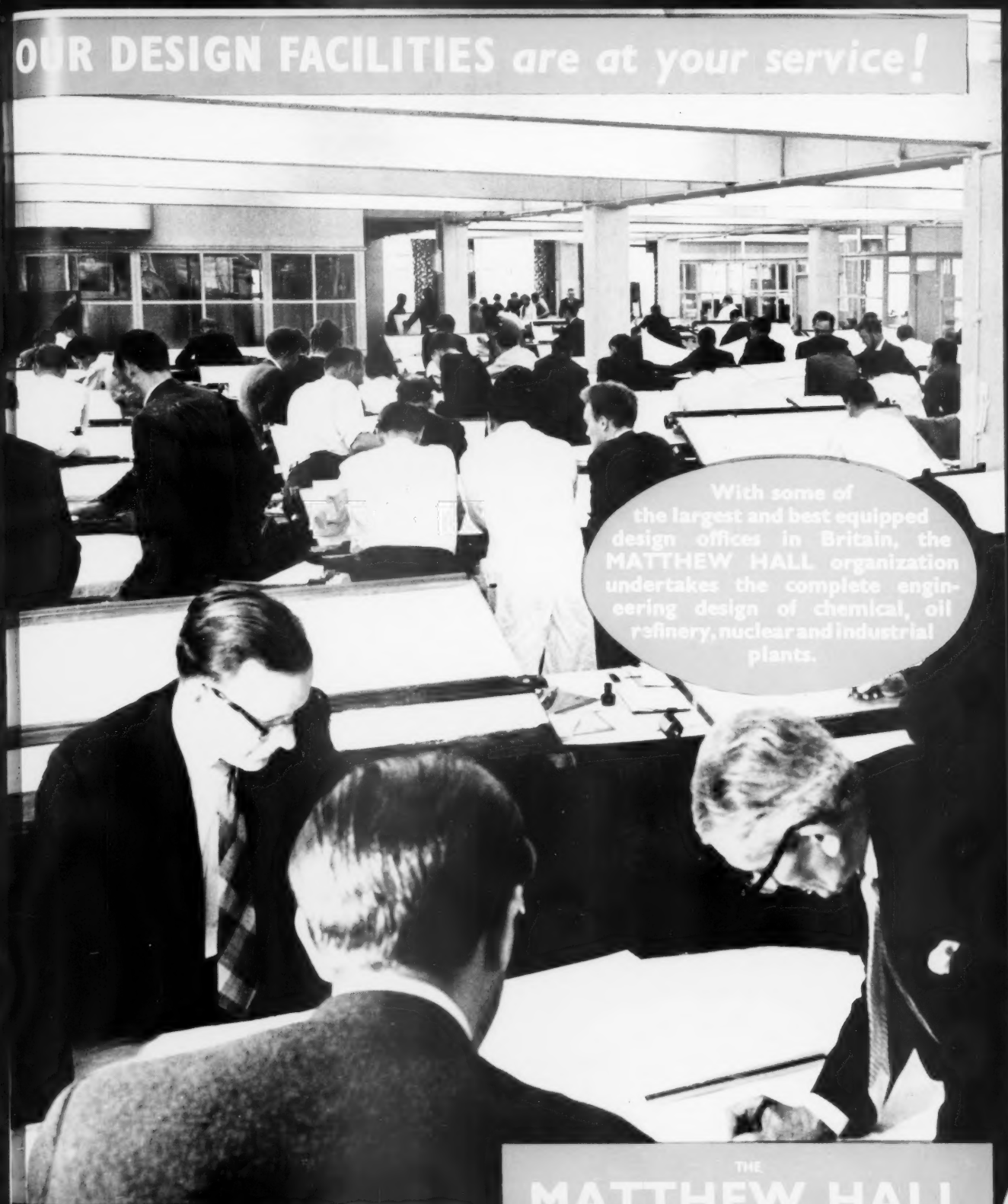

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